Discourse and prosody in sentence processing: An electrophysiological investigation

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Chapter 1: Introduction

> In früher Morgenstunde wurden die Verteidiger der Farm wieder geweckt. Der Tag schien ein warmer, ja heißer Sonnentag werden zu wollen und im freundlichen Morgenlichte nahm sich das gestern so düstere Gebäude heute ganz anders aus. Es war für viele Bewohner eingerichtet, aus Backsteinen gebaut, sehr lang und tief, und bestand aus dem Parterre und einem oberen Stockwerke mit plattem Dache. Die Fenster waren sehr hoch, doch so schmal, daß ein Mensch nicht hindurchkriechen konnte. Diese Vorsichtsmaßregel war in einer Gegend, welche oft von räuberischen Indianern durchzogen wird, sehr geboten. In jenen Gegenden kommt, oder wenigstens kam es oft vor, daß ein einsames Haus, eine Farm, mehrere Tage lang von den Bewohnern gegen solches Gesindel verteidigt werden mußte.
>
> […]
>
> Die Nordseite wurde schnell besetzt. Teils hielten die Verteidiger an den Schießscharten, teils standen sie auf den zwischen diesen befindlichen Erhöhungen, von denen aus über die Mauer geschossen werden konnte. Diese letzteren duckten sich nieder, um von den Angreifenden nicht zu früh gesehen zu werden. Der Trupp Tramps setzte sich in Bewegung, im Galopp gerade nach dem Thore zu. Erst als er sich höchstens noch achtzig Schritte von demselben befand, erscholl der Befehl zum Feuern; zwei Salven krachten schnell hintereinander, so genau abgegeben, daß sie wie zwei einzelne Schüsse klangen[1].

Stories like the example above have been told and re-told a thousand times, from bedside stories for little children to a blockbuster movie for adults. Although even young children can understand them, numerous sources of information play a role in the comprehension process. For instance, the meaning of the individual word is important as it determines whether the story tells of sheriffs or accountants. Syntactic information imposes a structure onto the sentence, making sure "The defender shot the tramp" describes a different event than "The tramp shot the defender". Prosody, the intonation and stress patterns of spoken language, can provide structural, pragmatic, and emotional information that may be crucial in understanding the story. The integration of these different sources of information unfolds rapidly in time and without much conscious effort.

This process, however, is not as straightforward as it may seem at first sight. Take for example a sentence like (1) and try to see which of the two persons is holding the binoculars (from Frazier, 1987).

(1) The spy saw the cop with the binoculars.

As is apparent, it is impossible to determine whether the spy is holding the binoculars, or whether the cop is holding the binoculars. This sentence is ambiguous between two possible readings. As this ambiguity is not resolved at the end of the sentence, this ambiguity is called a global ambiguity. Sentences can also be locally ambiguous. In a locally ambiguous sentence, an ambiguity arises and is resolved within the same sentence. Take for instance the well-known example sentence (2) (Bever, 1970).

(2) The horse raced past the barn fell.

When one encounters *raced*, this sentence is ambiguous between the active form *The horse raced…* and the reduced relative form of *The horse that was raced…*. Only when *fell* is

[1] From: Karl May (1894). Der Schatz im Silbersee. Union Deutsche Verlagsgesellschaft, Stuttgard.

encountered it becomes clear that the reduced form is the correct interpretation. Such sentences are called garden path sentences because they lead readers to believe that the active form of *raced* is the correct interpretation: It leads readers down a garden path.

In psycholinguistics, locally ambiguous sentences are often used to study sentence comprehension. The study of ambiguous sentences may provide information on what language users do when they are faced with an ambiguity. This can shed light on questions as: Do language users have a strategy to determine which of the possible alternatives to pursue, do they pursue all alternatives, or do they make no commitment and simply wait until the ambiguity is resolved by new information? A common way of studying the processing of ambiguous sentences is to measure the time that it takes readers to read the words of a sentence. The time it takes to read each word is taken as a measure of processing complexity. For example, for a sentence as (2), the reading times on *fell* can be compared with the reading times on *fell* in the sentence where the relative clause is not reduced (*The horse that was raced past the barn fell*). This comparison will show longer reading times on *fell* in the reduced relative sentence (2) compared to *fell* in the non-reduced sentence. From this it is inferred that readers prefer an active reading of *raced* over a reduced relative reading.

In the present thesis, sentences with a local ambiguity are used to address several questions on the processing of syntactic and non-syntactic information. The main question that will be addressed is whether there is an immediate interaction between prosodic information and syntactic information when they become available. To answer this question, the prosodic and syntactic information of interest have to be aligned to the exact same point in a sentence. As we will explain later in this introduction, this alignment is impossible when using sentences with a local ambiguity in isolation. Before we can turn to a discussion on why this is impossible in isolated sentences, and how this problem is resolved by placing the sentences in a discourse context, we will first discuss the individual ingredients of the upcoming series of experiments: theories of sentence processing, the role of prosody in auditory sentence processing, and Event-Related Potentials as a method to measure auditory sentence processing on-line.

1 Theories on sentence processing

Theories of sentence comprehension can be divided into two different main camps. The major difference between these two camps is the role of non-syntactic information in the comprehension process. In syntax-centered theories, syntactic information plays a central role, preceding all other possible sources of information, such as semantics, pragmatics, or prosody. In interactionist theories, all these sources of information operate simultaneously.

1.1 Syntax-centered theories

Syntax-centered theories are rooted in Chomsky's ideas on language (e.g., Chomsky, 1980). In syntax-centered theories, the process of understanding a sentence aims at a complete and unambiguous syntactic representation of that sentence. This syntactic parsing of the sentence is a modular process, meaning that it is unaffected by other-than-syntax types of information (see Fodor, 1983). That is, syntactic processing is informationally encapsulated from other sources of information such as semantic, pragmatic and prosodic information. In addition, the majority of syntax-centered theories assume that this parsing stage occurs before other sources of information come into play.

Within syntax-centered theories, Frazier's Garden Path Theory (e.g., Frazier, 1987) has a dominant role. This theory makes two basic assumptions about sentence comprehension.

The first assumption is that processing resources are limited. As a result, the parser has to minimize complexities to preserve resources. The second assumption is that in generating a candidate structure for a sentence, the parser uses exclusively syntactic information. Non-syntactic information only comes into play when no syntactic structure can be built based on syntactic information alone. In order to minimize complexity and preserve resources, the parser employs several parsing strategies. The two most important ones are Minimal Attachment and Late Closure. The Minimal Attachment principle holds that there is a preference for the syntactic analysis that creates the least number of nodes in the phrase structure tree (a hierarchical tree representation of the syntactic structure as in Figure 1). The Late Closure principle holds that, when possible, incoming lexical items should be attached into the clause that is currently being processed. Take for instance, for Minimal Attachment, fragment (3) of sentence (2). Before *fell* is encountered, the preferred interpretation is an active interpretation of the verb *raced* (left panel of Figure 1).

(3) The horse raced past the barn…

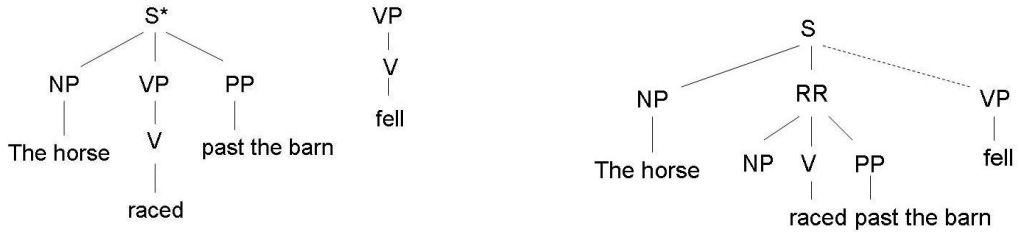


Figure 1. Phrase structure trees for the two readings of *The horse raced past the barn fell*; RR = Reduced Relative Clause

This active interpretation of *raced* is the preferred interpretation because the syntactic phrase structure tree for this interpretation (see left panel in Figure 1) requires fewer nodes than the reduced relative form of *raced* (see right panel in Figure 1).

In order to account for data that suggest an early role for non-syntactic information, more recently the original Garden Path Theory has been expanded to give non-syntactic information a more prominent role. In this later version, called Construal, Frazier and Clifton (1996, 1997) distinguish between primary and secondary phrases. Primary phrases are still governed only by the parsing principles from the original Garden Path Theory. These primary phrases include ambiguities that are structural in nature such as the main clause versus reduced relative clause ambiguity in (3). In these ambiguities, the alternative interpretations usually have completely different syntactic representations. In contrast, non-primary phrases are entered into the syntactic representation using the construal principle. These phrases are first associated with a thematic processing domain, and then interpreted within that domain using both structural (syntactic) and non-structural information. Non-primary phrases are elaborations of arguments, such as high versus low adverb attachment (*We remembered that the assignment will be due yesterday / tomorrow*), or high versus low adjunct clause attachment (*The doctor didn't leave because he was angry*).

1.2 Interactionist theories

In contrast to the two-stage modular theories, interactionist theories do not assume a separate encapsulated syntactic processing stage. Instead, all available sources of information (e.g., syntactic, semantic, and prosodic information) can play a role simultaneously. A commonly

proposed way of meshing up these different sources of information is by constraint satisfaction. In constraint satisfaction (potentially) conflicting sources of evidence compete with one another for dominance. In this process, the hardest constraint (e.g., the most prominent, or most active one) "wins", and as a result a sentence is interpreted along the line of the winning source of information.

The major difference between syntax-centered theories and interactionist theories lies in the role that non-syntactic information can play in the comprehension process. As interactionist theories allow for non-syntactic information to directly influence the parsing process, empirical evidence in favor of interactionist models usually shows a direct interaction between syntactic information and one or more non-syntactic sources of information. For example, several studies have shown that object relative clauses (as in (5); D: Dutch, LE: Literal English translation, E: correct English translation) are harder to understand than subject relative clauses (as in (4)) (e.g., Mak, Vonk, & Schriefers, 2002, 2006, 2008; King & Kutas, 1995; Schriefers, Friederici, & Kühn, 1995). Evidence for this comes from longer reading times on the auxiliary *hebben* in (5) compared to *heeft* in (4) for relative clauses in Dutch (where the sentences are ambiguous up to the occurrence of the auxiliary).

(4)
D: Morgen zal de professor, die de studenten ontmoet heeft, de diploma's uitreiken.
LE: Tomorrow will the professor, that the students met has, the diplomas present.
E: Tomorrow the professor, who has met the students, will present the diplomas.

(5)
D: Morgen zal de professor, die de studenten ontmoet hebben, de diploma's uitreiken.
LE: Tomorrow will the professor, that the students met have, the diplomas present.
E: Tomorrow the professor, whom the students have met, will present the diplomas.

However, Mak, Vonk, and Schriefers (2002) have shown that there is no difference in reading times on the auxiliary between subject relative clauses and object relative clauses when the antecedent of the relative clause is inanimate as *the computer* in (6) and (7). This finding shows that animacy influences the parsing of the relative clauses. This can only be the case if non-syntactic information, in this case semantic information, can contribute immediately to the parsing of the sentence.

(6)
D: Vanwege het onderzoek moeten de inbrekers, die de computer gestolen hebben, nog een tijdje op het politiebureau blijven.
LE: In the interest of the investigation must the burglars, that the computer stolen have, some time stay at the police station.
E: In the interest of the investigation, the burglars who had stolen the computer had to remain at the police station for some time.

(7)
D: Vanwege het onderzoek moet de computer, die de inbrekers gestolen hebben, nog een tijdje op het politiebureau blijven.
LE: In the interest of the investigation must the computer, that the burglars stolen have, some time stay at the police station.
E: In the interest of the investigation, the computer which the burglars had stolen had to remain at the police station for some time.

In addition to non-syntactic information within a sentence, sentence processing can be influenced by discourse information spanning across sentences. For instance, Altmann and Steedman (1988) studied the effects of referential context on the processing of ambiguous

prepositional phrases (PP) as in examples (8) and (9). The PP can be attached to the immediately preceding noun phrase (NP-attachment as in (8)), or can be attached to the preceding verb (VP-attachment as in (9)).

(8) The burglar blew open the safe *with the diamonds*. (NP-attachment)
(9) The burglar blew open the safe *with the dynamite*. (VP-attachment)

These sentences were embedded in contexts which introduced more than one candidate referent to the NP, that is, contexts which contained more than one *safe*. Under a syntax-first interpretation these contexts should not affect reading times since, irrespective of context, the PP will initially be interpreted as minimally attached to the VP (9). However, contrary to the predictions of the minimal attachment hypothesis, Altmann and Steedman showed that reading times on *with the diamonds* were shorter in a context mentioning more than one *safe* than in a context mentioning only a single *safe*. This suggests that contextual information is used immediately in the parsing process.

A different type of context manipulation has been used by Mak, Vonk, and Schriefers (2008). We will discuss it here in somewhat more detail as it concerns a manipulation of topic structure, a manipulation that will also play a role in the experiments of the present thesis. Mak, Vonk, and Schriefers (2008) investigated the processing of relative clauses in context. They embedded subject-relative clauses (B.1 in Table 1) and object-relative clauses (B.2 in Table 1) in contexts in which the relative clause-internal NP (*the burglar* in Table 1) either was the discourse topic or was not (A.2 vs. A.1 in Table 1). The experiment showed that the Subject-relative clause preference that is found for sentences in isolation, is also found in the Neutral Context condition. Reading times on the verb of the relative clause (*knocked down*) were longer for the object-relative clause than for the subject-relative clause. However, when the relative-clause internal NP (*the burglar*) is the discourse topic (as evoked in A.2), this difference in reading times was not present any more. This shows that discourse factors are able to guide the processing at the sentence-level.

Table 1. Materials of Mak, Vonk, and Schriefers (2008)

A.1: Neutral context
"Recently there has been a burglary in a villa in this area. The burglary has caused a lot of excitement. The media have devoted much attention to the case."
A.2: Topic context
"The burglar has been arrested during a burglary in a large villa. He wanted to steal some expensive jewelry from the house. He also wanted to take some money."
B.1: Subject-relative clause[1]
D: De politie heeft de bewoners, die de inbreker hebben neergeslagen, verteld dat de man nog meer misdaden heeft gepleegd.
LE: The police have the occupants, that the burglar have knocked down, told that the man has committed more crimes.
E: "The police have told the occupants, who have knocked down the burglar, that the man has committed more crimes."
B.2: Object-relative clause[1]
D: De politie heeft de bewoners, die de inbreker heeft neergeslagen, verteld dat de man nog meer misdaden heeft gepleegd.
LE: The police have the occupants, that the burglar has knocked down, told that the man has committed more crimes.
E: "The police have told the occupants, whom the burglar has knocked down, that the man has committed more crimes."
C: Exit sentence
"The police are glad that the burglar has been arrested."

[1] D: Dutch, LE: Literal English, E: English

Mak, Vonk and Schriefers explain their results in terms of the topichood hypothesis (2002, 2008). This hypothesis is inspired by the fact that there is a strong correlation between the topic and the subject of a sentence: Usually, the topic of a sentence is referred to by the syntactic subject (cf. Lambrecht, 1994, p.131). For relative clauses, the topichood hypothesis claims that the entity in the relative clause that is most topicworthy will be chosen as the

subject. By default, the antecedent of the relative clause (*the occupants* in B.1 and B.2 of Table 1) will be chosen as the subject of the relative clause, because it is the head of the relative clause and, therefore, topicworthy. However, when also the noun phrase in the relative clause is made topicworthy by the preceding context, the preference for the antecedent to be the subject will disappear. As we indicated above, a topic manipulation will also play an important role in the present thesis.

2 Prosody in auditory sentence processing

The majority of research on sentence comprehension has been conducted in the visual modality. The auditory modality, however, provides an additional rich source of information: prosody. Prosody refers to a number of different aspects of the speech signal, such as pitch (the relative fundamental frequency of speech), amplitude (loudness of the speech signal), tempo, and pauses. Sentence comprehension and prosodic processing are clearly related. The prosody of a sentence can change its interpretation completely. For example, a rising pitch instead of a level pitch on *John* in the sentence *Jack hit John* transforms the sentence from a declarative sentence into a question.

A reason that the auditory modality has not been given the same attention as the visual modality may be that it is difficult to conduct experiments in the auditory modality. Because of the continuous nature of the speech signal, it is difficult to find a good measure of sentence processing. In contrast to the visual modality, it is not possible to measure the processing times on each subsequent word in a sentence (as done in self-paced reading or by measuring of eye movements in reading studies). A solution to this problem is the use of a secondary task. In the literature two kinds of secondary task have been used, offline tasks and online tasks. In offline tasks, participants are presented with sentences or parts of sentences and have to perform an additional task (usually) in a different modality. For instance, in several studies participants listened to sentences in which, at a certain point, a click is presented. The participants' task was to indicate when the click was presented by marking it in a written text at the end of the sentence presentation or by writing the sentence down and indicating where the click occurred (e.g., Abrams & Bever, 1968; Geers, 1978). In a similar paradigm, the signal switches from one side of the headphones to the other. Again, participants have to indicate where the switch occurred (e.g., Wingfield & Klein, 1978). Other paradigms include memory-based tasks like the recall of auditorily presented nonsense syllables (e.g., Leonard, 1974). The drawback of experiments using an offline secondary task is that, although they do provide information on aspects as linguistic preferences or memory performance, they do not provide a window on the online comprehension processes.

Alternatively, the secondary task may be an online task in which reaction times can be measured. A frequently used task is to present a probe at a certain point in the sentence, to which participants have to respond. This probe can either be a click or beep in response to which participants have to press a button, or a visually presented a word they have to read out loud. The time it takes to respond to the probe is taken as a measure of processing difficulty (e.g., Marslen-Wilson et al., 1992; Watt & Murray, 1996).

Results from both offline studies and online studies have shown that prosodic information can affect language comprehension at all levels of processing. A large proportion of the research on prosodic processing has focused on the word- and syllable level. For instance, segmental timing in syllables can disambiguate between ambiguous strings like *le couplet complet* versus *le couple est complet* (Rietveld, 1980). Chistophe et al. (2004) have shown that a break versus continuity ambiguity on the word level (e.g., *chat grincheaux* [a grumpy

cat] vs. *chagrin* [sorrow] can be disambiguated by a phonological boundary between *chat* and *grincheaux*.

Prosody also plays an important role in sentence comprehension. Early studies using offline tasks have established that the prosodic structure of an utterance plays an organizing role in speech recognition (Cutler, Dahan, & Van Donselaar, 1997). For instance, the well-known effect (Epstein, 1961) that a string of nonsense syllables is remembered better when they are presented with sentence morphology (*meeving gups keebed gompily*) than without (*meev gup keeb gomp*) only holds in the auditory modality if the syllables are presented with a sentence-like prosodic contour. If they are read as a list, no such advantage is present (e.g., Leonard, 1974). Also, listeners can indicate major syntactic breaks by prosody alone when listening to delexicalized sentences (e.g., Collier & 't Hart, 1975; De Pijper & Sanderman, 1994). In addition, prosody is able to disambiguate syntactic ambiguities through prosodic boundaries. For example, bracketing ambiguities (e.g., see (10) vs. (11)) can be disambiguated by means of a pause. The fragment "Old men and women" with a pause following *old* will be interpreted as indicated in Example (10); in contrast, with a pause following *men* the fragment will be interpreted as indicated in Example (11) (Shattuck-Hufnagel & Turk, 1996).

(10) (old) (men and women)…
(11) (old men) (and women)…

Finally, prosodic information appears to play an important role in building up the discourse structure. Discourse processing is facilitated by accentuation of new information, and deaccentuation of old information (e.g., Gernsbacher & Jescheniak, 1995). However, in production, speakers do not mark topic structure systematically (see Cutler, Dahan, & Van Donselaar, 1997, p. 180), but when corresponding prosodic information is present in the signal, listeners will make use of this information (see Grosz & Hirschberg, 1992, and Grosz, Hirschberg, & Nakatani, 1994).

In the present thesis, we investigate the interaction of prosodic information and syntactic information in sentence processing. Overall, it is uncontroversial that prosody can in principle affect syntactic processing. However, to date little is known about how prosody interacts with syntax on a local level (Cutler, Dahan, & Van Donselaar, 1997). Despite the clear relationship between prosody and syntax, they are not isomorphic. Not all aspects of syntax are signaled in the prosodic structure of a spoken utterance, and vice versa, many prosodic aspects of spoken utterances cannot be predicted from the morphosyntactic structure of the sentences (see Shattuck-Hufnagel & Turk, 1996, and Cutler, Dahan, & Van Donselaar, 1997, for reviews). Furthermore, it should be noted that in all the above examples the effect of the prosodic information is always measured after the relevant prosodic information occurred, either several words downstream, or at the end of the sentence.

In this thesis, the type of prosodic information of interest is an intonational phrase boundary (IPh), henceforth referred to as a prosodic break. A prosodic break is characterized by a pitch-rise on the last syllable before a pause, directly followed by this pause. Sometimes the pitch-rise on the last syllable is combined with a lengthening of this syllable, called pre-final lengthening. For an intuitive approach, a prosodic break can be characterized as the way a comma is "pronounced".

Because we will be addressing the question whether there is a direct and immediate interaction between prosodic information and syntactic information, the use of a secondary task is unsatisfactory. Fortunately, there is a direct way to measure the processing of auditory sentences: Event-Related Potentials (ERPs). The following section will describe the ERP methodology and the language-related ERP components that play a role in this thesis.

3 Event-Related Potentials

Event-related potentials are part of the ongoing electrical activity of the brain that can be measured from the scalp, known as the electroencephalogram (EEG).
The EEG reflects small voltage fluctuations that are caused by simultaneous post-synaptic activity of a large population of neurons in the cerebral cortex and thalamocortical connections that fire in synchrony. The EEG can be measured by placing electrodes on the scalp. The EEG is measured differentially, meaning that an active electrode is placed over a brain area of interest and the activity of an electrically silent passive reference electrode, is subtracted from it. Usually the left and right mastoids are used as locations for the reference electrodes. The mastoids are considered to be unaffected by the electrical brain activity. Relative to the EEG, the amplitude of ERPs are very small, ranging from less than 1 μV to about 10 μV against 10 to 100 μV of the ongoing EEG.

In order to extract ERPs from the raw EEG signal, a number of steps have to be taken. First, the EEG signal that is measured during an experiment with several conditions is cut into single trials. Second, these trials are time-locked to the event of interest. Third, the trials are checked for the occurrence of artifacts. Trials in which the EEG signal is contaminated by artifacts, like eye movements, are then removed. In the final step in creating Event-Related Potentials, multiple EEG recordings from a given experimental condition are averaged. EEG activity that is not time-locked to the critical event is cancelled out by this averaging because on average the phase and amplitude of random EEG activity are zero. The majority of studies use a within-participant repeated measure design. This means that for each participant multiple EEG trials are measured for all the conditions in the experiment. Language studies generally use at least 25 trials per condition (Kutas & Van Petten, 1994).

The ERPs that result from the averaging procedure show a series of positive and negative deflections. These so-called components are thought to reflect specific cognitive processes. They are usually named after the component's polarity and peak-latency or distribution. For instance, a component that is reliably elicited after syntactic violations or syntactic ambiguities is the P600. The P600 is a positive deflection peaking around 600 ms after the onset of the syntactic violation (e.g., Hagoort, Brown, & Osterhout, 1999). In the following, we will briefly describe language-related ERP components that are of special interest for the present research.

3.1 The N400

The N400 is an ERP component that is sensitive to semantics. This component is a negative peak that is elicited on average 400 ms after the onset of a content word (Kutas & Hillyard, 1984). The peak is usually largest over the centroparietal midline and centroparietal bilateral sites. The amplitude of this negative peak is inversely related to the degree a content word is expected based on the previous context. For example, the N400 to *socks* in *He spread the warm bread with socks* is larger than the N400 to *butter* in the sentence *He spread the warm bread with butter*. This reduction in amplitude has been called the N400-effect. The N400-effect has been shown in response to single words (e.g., Holcomb 1993; Chwilla, Brown, & Hagoort, 1995; Chwilla, Hagoort, & Brown, 1998), in sentence context (e.g., Friederici, 1995; Van Petten, Coulson, Rubin, Plate, & Parks, 1998), and in discourse context (e.g., Van Berkum et al. 2003). The N400 is thought to reflect lexical-semantic integration processes, and is used as a measure of how well a word fits semantically in the context (Chwilla, 1996).

3.2 The Left Anterior Negativity and P600

For the syntactic domain, two main ERP components have been identified: the Left Anterior Negativity and the P600. The Left Anterior Negativity (LAN) is an early negative ERP component which is typically found over the left-anterior region of the scalp (Friederici, 1995). The timing of the LAN ranges from around 100 ms to around 400 ms after a syntactic error. It has been suggested that the exact timing of the LAN is a function of the type of violation by which it is elicited. For instance, word category violations have been found to elicit a very early LAN (the so-called ELAN, e.g., Friederici, Hahne, & Mecklinger, 1996), whereas morphosyntactic violations, such as subject-verb agreement errors, have been found to elicit a later LAN. Whether the LAN reflects a single process, or is elicited by different processes is still unclear (e.g., see Münte et al., 1997). The LAN, and especially the ELAN, is thought to reflect the detection of syntactic errors (such as word category or subject-verb agreement errors; e.g., Hahne & Friederici, 1999). In addition, the LAN has also been observed in the processing of grammatically correct sentences that make a high demand on working memory (e.g., King & Kutas, 1995; Rösler et al., 1998). Therefore, the LAN has also been considered as a more general index of working memory load.

The second component that is associated with syntactic processing is the P600. The P600 is a positive shift which starts around 500 ms and typically lasts until about 800 ms after the onset of a critical event. The component is usually characterized by a centroparietal scalp distribution (Osterhout & Holcomb, 1992), although more anterior distributions are also reported (e.g., Hagoort & Brown, 2000). The P600 is elicited in response to a variety of syntactic anomalies (see for a review Vos et al., 2001). Most relevant for this thesis is the finding that a P600 is also elicited by the syntactically disambiguating lexical element in locally ambiguous sentences and other syntactically non-preferred structures (e.g., Hahne & Friederici, 1999; King & Kutas, 1996; Friederici, Steinhauer, Mecklinger, & Meyer, 1998).

In addition, P600-like effects have also been observed in other structure sensitive domains. For instance, Patel et al. (1998) have shown that structural incongruities in music elicit a P600 in musically educated adults that is statistically indistinguishable from a P600 that is elicited by linguistic stimuli. Overall, the P600 is usually interpreted as a reflection of a syntactic reanalysis and repair process (e.g., Van Herten et al., 2005, but see for example Kuperberg, 2007 for different interpretations).

3.3 The Closure Positive Shift

The central ERP component in this thesis is the Closure Positive Shift (CPS). The CPS is sensitive to the type of prosodic information that will be the focus of this thesis: prosodic breaks. The CPS is a large positive shift with a right-posterior or bilateral-posterior distribution that occurs between 400 and 800 ms after the onset of a prosodic break (though earlier onsets have also been observed in the literature, e.g., Steinhauer, Alter, & Friederici; 1999). The CPS was first described by Steinhauer et al. (1999). Steinhauer et al. compared sentences that contained a prosodic break at a certain point in the sentence to the same sentences without a prosodic break at that point. This contrast yielded a large positive deflection. In a series of follow-up experiments, Steinhauer (2003) investigated whether this CPS was attributable to the pause of a prosodic break. The results showed that a CPS is not elicited by the pause of a prosodic break alone, as sentences in which the pause was deleted still elicited a CPS.

What the CPS reflects precisely is unclear. The CPS is also found in sentences without any semantic content (jabberwocky sentences), sentences without any semantic or syntactic content (pseudo-sentences), and even in hummed sentences (i.e., sentences with only the prosodic contour of spoken sentences without any lexical content; Pannekamp et al., 2005).

Additionally, it is found in the visual modality as a response to commas (Steinhauer & Friederici, 2001). The last finding suggest that the CPS reflects more than a mere reaction to the physical signal of a prosodic break in speech. It could, for instance, reflect a more general process of the structuring of incoming (linguistic) information.

4 The interaction of syntactic information and prosodic information

In this section we will describe the local ambiguity, the so-called coordination ambiguity, that is used in the present thesis to study the direct interaction of prosodic information and syntactic information. We will discuss some evidence on the processing of isolated coordination sentences. Additionally, we show that it is impossible to align syntactic and prosodic information to the same point in a sentence when using isolated sentences. Finally, we will describe a solution to this alignment problem by a context manipulation.

4.1 The coordination ambiguity

The local ambiguity that is used in this thesis is the coordination ambiguity. Consider sentence fragment (12). After reading *the farm hand,* this sentence fragment can continue as in sentence (13), in which *the farm hand* is the start of a new sentence, or as in sentence (14) in which *the farm hand* is a continuation of the coordinated Noun Phrase *the farmer and….* Both sentences could have occurred in a context as presented in the story at the beginning of this thesis.

(12) The sheriff protected the farmer and the farm hand…
(13) The sheriff protected the farmer and the farm hand defended bravely the ranch against Johnson's gang.
(14) The sheriff protected the farmer and the farm hand in front of the shed where a fight was fought

A continuation as in (13) is called an sentence coordination (henceforth an S-coordination), because the noun phrase following the connective *and* is the subject of a new sentence (*the farm hand defended…*). A continuation as in (14) is called a noun phrase coordination (henceforth an NP-coordination), because the NP following *and* is part of a complex NP of two NPs in which the connective *and* glues the two NPs together (*the farmer and the farm hand*). Previous research on this local ambiguity has shown that, for sentences in isolation, readers have a preference for the NP-coordination interpretation (Frazier, 1987; Hoeks, Vonk, & Schriefers, 2002; Hoeks et al., 2005).

The first study on the processing of sentences with such a coordination ambiguity in Dutch was a self-paced reading experiment conducted by Frazier (1987). The coordination sentences were disambiguated as an NP-coordination (15), or as an S-coordination (16) by the last segment of the sentence. Reading times on this final segment were recorded.

(15) Pete kissed Mary and her sister too.
(16) Pete kissed Mary and her sister laughed.

Reading times on the disambiguating region of the NP-coordination (*too* in (15)) were shorter than reading times on the final section of the S-coordinations (*laughed* in (16)). According to Frazier the longer reading times for the S-coordinations (1596 ms on *laughed* vs. 1222 ms on *too*) reflect processing difficulty for the S-coordination sentences. This processing difficulty occurs because readers have interpreted *her sister* as a part of the complex NP *Mary and her sister*. Upon reading *laughed*, readers have to revise their initial

interpretation and to conclude that *and her sister* was not a part of a complex NP, but rather the start of a new clause. This re-analysis is reflected in longer reading times on the verb *laughed*.

Why would readers initially interpret *her sister* as part of a complex NP *Mary and her sister*, instead of as the start of a new sentence? That is, why do they prefer an NP-coordination interpretation of the ambiguity over an S-coordination interpretation? One possible explanation would be in terms of syntactic theory: NP-coordination sentences are preferred because they are syntactically less complex than S-coordination sentences. Alternatively, it might be the case that readers disprefer S-coordination sentences for pragmatic reasons. That is, S-coordination sentences contain two topics (*Pete* and *her sister* in (16)), whereas NP-coordination sentences contain one topic (*Pete* in (15)). Readers might disprefer the introduction of a new topic in the middle of a sentence that they are currently processing.

Hoeks et al. (2005) tested the syntactic hypothesis in an eye-tracking study in which they looked at the effect of thematic fit on the processing of sentences with a coordination ambiguity. They presented ambiguous S-coordination sentences and S-coordination sentences that either were disambiguated by means of a comma towards an S-coordination, or had no comma, and thus remained ambiguous (see (17) and (18)). The third NP of the S-coordination sentences either was a plausible theme for the first verb (e.g., *the cop* in (17)), or was an implausible theme for the first verb (e.g., *the carpenter* in (18)). In the poor thematic fit condition it is semantically implausible that *the carpenter* is the object of the verb *to sand*. If the thematic fit has an effect on the processing of the coordination ambiguity, it should reduce or negate the NP-coordination preference in the poor thematic fit condition relative to the good thematic fit condition. That is, the second verb in the ambiguous good fit condition (*risked* in (17)) should show reflections of a processing difficulty relative to the verb in the unambiguous good fit condition. By contrast, this processing difficulty at the verb should be absent in the poor fit condition both in the unambiguous condition and in the ambiguous condition. In other words, this should result in an interaction between the factor ambiguity and the factor thematic fit.

(17) The thief shot the jeweler(,) and the cop risked his life during the ensuing fight.
(18) Jasper sands the board(,) and the carpenter scrapes the paint from the doors.

This predicted interaction was found at the region following the disambiguating verb[2]. This interaction reflected the presence of a processing difficulty in the good fit sentences, and the absence of a processing difficulty in the poor fit sentences. These results seem to indicate that thematic information can be used rapidly to reduce the processing difficulty in ambiguous S-coordination sentences. However, a detailed analysis of the results showed that there was still an effect of ambiguity present in the poor fit sentences. That is, the processing of *scrapes* in (18) took more time in the ambiguous condition (without a comma) than in the unambiguous condition (with a comma)[3]. The reason for this might be that although processing difficulty is reduced, the sentences are not altogether disambiguated by the thematic information because this information is not strong enough.

[2] In online sentence comprehension it is common to find effects of a word (e.g., a disambiguating verb) not on the word itself, but one or two words "downstream". This phenomenon is called spill-over.

[3] Reading times at the position of the second noun (*the cop* in the good fit condition and *the carpenter* in the bad fit condition) were faster for the unambiguous sentences (with a comma) than for the ambiguous sentences (without a comma). No interaction between Ambiguity and Thematic Fit was found at this location.

4.2 The problem of measuring the immediate interaction of prosody and syntax

To study the immediate interaction of prosodic and syntactic information, locally ambiguous coordination sentences will be used. In order to study this interaction, we have to align the availability of the syntactic and prosodic information to the same point in the sentence. The prosodic information of interest is the presence or absence of a prosodic break at and following *the farmer* in (13) and (14) (here repeated as (19) and (20)) (in the following we will refer to this break as a "prosodic break following *the farmer"*). This is the location where, in the visual modality, either a comma is present or not. By hypothesis, we take the prosodic break to be an auditory analogue of a comma that is able to disambiguate the locally ambiguous coordination sentences in the auditory modality. Whether this is actually the case will be studied in Chapter 2.

(19) The sheriff protected the farmer and the farm hand defended bravely the ranch against Johnson's gang.
(20) The sheriff protected the farmer and the farm hand in front of the shed where a fight was fought.

The syntactic information of interest is the presence of a syntactic break at the same point: following *the farmer* in (19) and (20). We know from the literature that a comma at this location disambiguates the sentence as an S-coordination (e.g., Hoeks et al. 2005). However, in the absence of a comma, the syntactic break following *the farmer* only becomes apparent at the disambiguating verb (*defended* in (19)) several words downstream. If we want to study the immediate interaction between prosodic information and syntactic information, we have to move the point at which the syntactic break becomes apparent to the same point at which the prosodic break occurs. In isolated sentences this appears to be impossible.

4.3 Processing coordination sentences in context

In the present thesis, a context manipulation, described in Hoeks, Vonk, and Schriefers (2002), is used to align the syntactic information and the prosodic information to the same point in the sentence. Before explaining the context manipulation in more detail, we will first discuss the experiments of Hoeks, Vonk, and Schriefers.

Hoeks, Vonk, and Schriefers (2002) studied the processing of S-coordination sentences (C in Table 2) that are embedded into discourse contexts (B.1 and B.2 in Table 2). In these contexts, the discourse topic structure was manipulated. In a so-called S-coordination biasing context sentence (B.2; henceforth called biasing context) both the first NP of the coordination sentence (*the model*) and the third NP of the coordination sentence (*the photographer*) are introduced as discourse topics. By contrast, in the neutral context sentence (B.1) a general scene was set up, in which the NPs of the coordination sentence fit naturally.

Table 2. Example of materials used by Hoeks, Vonk, and Schriefers (2002).

A: Lead-in sentence
The new collection of evening dresses that was presented that night really struck home in the fashion world of Paris.
B.1: Neutral context
It was therefore not surprising that the party afterwards was exhilarating.
B.2: Biasing context
When they met the designer at the party afterwards, the model and the photographer were very enthusiastic.
C: Target sentence (with comma unambiguous, without comma ambiguous)
The model kissed the designer(,) and the photographer opened smiling a bottle of champagne.
D: Exit sentence
This was surely a memorable evening.

The results from a self-paced reading task and an eye-movement study showed that for S-coordination sentences in a neutral context, the reading times on the disambiguating verb were longer in ambiguous S-coordination sentences than in S-coordination sentences that were disambiguated by means of a comma. This finding confirmed the finding with isolated sentences that, in the absence of any cues for an S-coordination interpretation, the coordination sentence is preferably analyzed as an NP-coordination. However, the results in the biasing context showed no differences in the reading times on the disambiguating verb of the ambiguous and disambiguated S-coordination sentences. These results show that if both the first NP (*the model*), and the third NP (*the photographer*) are introduced as discourse topics, the S-coordination sentences without a comma are disambiguated before the onset of the disambiguating verb.

Why would the discourse context in which the first NP (*the model*) and the third NP (*the photographer*) are introduced as discourse topics disambiguate the target sentences as S-coordination sentences before the disambiguating verb? To explain this, Hoeks, Vonk, and Schriefers introduced two principles of topic structure. The first principle is the principle of minimal topic structure. This principle holds that in the absence of any cues or additional information, the simplest topic structure (the topic-comment structure) is the preferred topic structure. In other words, by default readers and listeners assume one topic per sentence. The second principle is topic continuity (Givón, 1983). If a discourse entity has fulfilled the role of topic earlier in a discourse, then there is a preference for having that same entity take the role of topic in a new sentence. That is, readers and listeners have a preference for coherent discourses that are about the same topic. According to the principle of topic continuity, both *the model* and *the photographer* want to remain topic throughout the discourse. Because of the strong correlation between the topic role and the function of syntactic subject (Li & Thompson, 1976), the entity that is most topic worthy, also wants to become the subject of a sentence. That is, because both *the model* and *the photographer* are topics, they both want to be syntactic subject. The easiest way to accomplish this is to assume that *the photographer* is the onset of a new clause, and thus to assume a syntactic break following *the model*.

The context manipulation of Hoeks, Vonk, and Schriefers (2002) allows us to induce the expectation of a syntactic break well before the onset of the lexically disambiguating information (i.e., the verb *opened* in the target sentence in Table 2). This provides a solution to the problem of aligning prosodic and syntactic information. In the biasing context, a syntactic break is expected following NP2, whereas no syntactic break should be expected in the neutral context. The position following NP2 is also the position at which the critical prosodic information, a prosodic break, occurs as an auditory analog of a comma. Embedding coordination sentences with and without a prosodic break in biasing and neutral contexts will thus allow to investigate the immediate interaction between syntactic information and prosodic information.

5 Structure of the thesis

This dissertation will present the results from four ERP experiments. The main question to be addressed by this series of experiments is whether syntactic information and prosodic information interact immediately when they become available. Before we will turn to the direct interaction of syntax and prosody, the processing of the coordination ambiguity in isolation will be investigated in two experiments, one in the visual and one in the auditory modality. The main question to be answered in these experiments is whether a prosodic break can indeed serve as an auditory analogue of a comma. These experiments are reported in Chapter 2, which has been published in Brain Research under the title of the chapter (Kerkhofs, Vonk, Schriefers, & Chwilla, 2008).

The main question of the thesis is whether syntactic information and prosodic information interact immediately when they become available. This question will be addressed in Chapter 3. To answer this question, two auditory experiments were conducted. In these experiments, syntactically ambiguous coordination sentences were embedded in neutral and biasing contexts. The sentences either contained a prosodic break or did not contain a prosodic break. To measure the direct interaction between syntax and prosody, we looked at the ERPs at the position at which the prosodic information and the syntactic information are aligned (the location where a prosodic break is present or not). The main part of Chapter 3 is published in Journal of Cognitive Neuroscience under the title of the chapter (Kerkhofs, Vonk, Schriefers, & Chwilla, 2007). Chapter 3 also contains two supplementary analysis sections, in which data from the two experiments that were not included in the published article are further explored.

Chapter 4 reports the data at the location of the lexically disambiguating region, obtained in the same experiments as reported Chapter 3. This chapter will explore the combined effects of contextually induced syntactic expectations and prosodic information on the processing of the syntactically disambiguating region of the coordination sentences. Additionally, the question whether the absence of a prosodic break can be a cue for syntactic continuity will be addressed.

Chapter 5 compiles and discusses the findings from Chapters 2 to 4.

Appendix I presents a methodological discussion on the choice of the time-locking points that were used in the analyses at the disambiguating verb in Chapters 2 and 4. In this appendix, three time-locking points for analyzing the ERP results for auditory ERP experiments are contrasted. Appendix II contains the stimulus materials that were used in the visual modality (Experiment 1), and the auditory modality (Experiment 2) in Chapter 2, and Appendix III contains the stimulus materials of the experiments reported in Chapters 3 and 4.

Both Chapter 2 and Chapter 3 are in the format in which they were published, with the exception of cross-links to other chapters. This results in inevitable overlap in the introductions of both chapters. The sections within the chapters are presented in the order that was required by the respective journals (as a consequence, in Chapter 2 the Methods section is presented following the General Discussion). The references from these two chapters and the other chapters are compiled into a single list that is included at the end of this thesis. References to tables, figures, footnotes etc. are numbered consecutively within each chapter. Although Chapter 2 was published in 2008 and Chapter 3 was published in 2007, the experiments from Chapter 2 were carried out before the experiments reported in Chapters 3 and 4.

Chapter 2: Sentence processing in the visual and auditory modality: Do comma and prosodic break have parallel functions?[1]

Abstract

Two Event-Related Potential studies contrast the processing of locally ambiguous sentences in the visual and the auditory modality. These sentences are disambiguated by a lexical element. Before this element appears in a sentence, the sentence can also be disambiguated by a boundary marker: a comma in the visual modality, or a prosodic break in the auditory modality. Previous studies have shown that a specific ERP component, the Closure Positive Shift (CPS) can be elicited by these markers. The results of the present studies show that both the comma and the prosodic break disambiguate the ambiguous sentences before the critical lexical element, despite the fact that a clear CPS is only found in the auditory modality. Comma and prosodic break thus have parallel functions irrespective of whether they do or do not elicit a CPS.

1 Introduction

The majority of ERP research on sentence processing has been carried out in the visual domain (see for reviews: Kutas & Schmitt, 2003, and Osterhout et al., 2004). By contrast, only a relatively small number of studies on connected speech have been conducted. On the whole similar ERP signatures for semantic and syntactic anomalies have been observed in the visual and auditory domain (Friederici et al., 1993; Hagoort & Brown, 2000; Holcomb & Neville, 1991; Osterhout & Holcomb, 1993). Even less frequent than auditory studies on sentence processing are direct comparisons of sentence processing in the visual and the auditory domain.

To our knowledge there are only two studies on sentence processing that directly compare ERPs across modalities, one in Dutch (Hagoort & Brown, 2000), and one in Italian (Balcony & Pozzoli, 2005). Both studies looked at ERPs elicited by syntactic violations. They reported similar P600 effects for the visual and the auditory modality. In particular, for Dutch, the language used in the present article, Hagoort and Brown (2000) observed similar P600 effects in terms of both the overall scalp distribution (though the auditory effect showed a more anterior distribution) and the timing of the effect. From this they concluded that core aspects of parsing operations are identical across the two domains of input.

In the present paper, we focus on a direct comparison of ERP correlates in the visual and the auditory domain while participants process locally ambiguous sentences. In contrast to the studies mentioned above, the sentences in the present experiment are correct sentences and do not contain syntactic or semantic violations. Rather, we will compare the effects of the signaling of a syntactic break in locally ambiguous sentences across modalities. In the visual domain, the presence or absence of a syntactic break can be signaled by the presence or absence of a comma. A potential analog in the auditory domain concerns the presence or absence of a prosodic break.

[1] This chapter has been published as: Kerkhofs, R., Vonk, W., Schriefers, H., & Chwilla, D. J. (2008). Sentence processing in the visual and auditory modality: Do comma and prosodic break have parallel functions? *Brain Research*, *1224*, 102 – 118.

Before turning to a more specific discussion of the type of ambiguity used in the present study, we will first provide an overview of language-related ERP components. The most important ERP component for the semantic domain is a negative wave peaking at about 400 ms, called the N400 (Kutas & Hillyard, 1984). A well-established view is that modulations in N400 amplitude reflect the ease with which a word is integrated into the current context, be this a single word (Chwilla et al., 1998), a sentential context (Friederici, 1995), or a discourse context (Van Berkum et al., 1999).

For the syntactic domain, two main ERP components have been identified (for an overview, see Friederici, 1995). The first component is an anterior distributed negative potential, which typically occurs to words that render the sentence incorrect (Friederici et al., 1993; Kluender & Kutas, 1993; Neville et al., 1991; Rösler et al., 1993). Although the topography of this negativity varies somewhat between studies, it often shows a left anterior maximum and therefore is called the Left Anterior Negativity (LAN) (Friederici, 1995). The timing of this negativity has been proposed to differ as a function of the kind of syntactic violation involved. In particular, phrase structure violations (i.e., word category errors) elicit an immediate effect between 100 to 300 ms after stimulus onset (Hahne & Friederici, 2002), whereas morphosyntactic violations (e.g., subject-verb agreement errors) elicit an effect between 300 to 500 ms after stimulus onset. With respect to the functional significance, it has been proposed that the LAN reflects a syntactic process (Friederici, 2002). It has also been suggested that the LAN reflects a general index of working-memory load [2] (King & Kutas, 1995).

The second syntax-related ERP component is a late centroparietally distributed positive potential starting at about 500 ms and typically extending up to at least 800 ms. This positivity is usually referred to as P600. An increase in P600 amplitude has been observed in response to various kinds of syntactic violations like phrase structure violations (Friederici et al., 1996; Neville et al., 1991; Osterhout & Holcomb, 1992, 1993), subjacency violations (McKinnon & Osterhout, 1996; Neville et al., 1991) and agreement violations (for an overview, see Vos et al., 2001). P600 effects have also been observed in locally ambiguous sentences at the disambiguating lexical element (Friederici et al., 1999; Osterhout & Holcomb, 1992; Osterhout et al., 1994). While the P600 effect to syntactic violations shows a posterior scalp distribution (Coulson et al., 1998), a more anterior or a broader scalp distribution of the P600 effect has been reported in locally ambiguous sentences at the disambiguating element (Friederici et al., 1996; Hagoort et al., 1999; Osterhout & Holcomb, 1992; Van Berkum et al., 1999). The P600 is generally conceived of as reflecting processes of revision and repair in sentence processing. It should be noted, however, that recent evidence suggests that the N400 and the P600 are not necessarily distinct, in the sense that they only occur within their own semantic or syntactic domain (e.g., Kim & Osterhout, 2005, and Schlesewsky & Bornkessel, 2006).

In the present study, we use locally ambiguous sentences that allow for two different syntactic analyses up to a certain point in the sentence after which the sentence becomes disambiguated by a lexical element, as exemplified in (1) and (2). These sentences are ambiguous up to and including the noun phrase *the policeman*, and they are disambiguated at the word following this noun phrase (in (2)) or at least at the end of the sentence (in (1)). In (1), the prepositional phrase *in front of the statue* suggests that the coordinated noun phrase *the squatter and the policeman* is the object of the verb *interviewed* (noun phrase

[2]One argument in favor of the latter view is that lexically ambiguous words like *bank* have been reported to elicit very similar anterior distributed negativities (Ischebeck et al., 2008). Such ambiguities are not syntactic but can be assumed to tax verbal working memory more heavily than sentences without lexical ambiguities.

coordination; NP-coordination), because it is more likely for *in front of* to set the scene in which the action is taking place than indicating the place at which only the policeman (but not the squatter) is located. In (2), the verb *interrupted* indicates that the noun phrase *the policeman* is the subject of a new sentence (sentence coordination; S-coordination).

(1) The reporter interviewed the squatter and the policeman in front of the statue in the centre of the city.
(2) The reporter interviewed the squatter and the policeman interrupted the interview right away.

In the present paper, we study the processing of the Dutch equivalents locally ambiguous sentences as (2) (henceforth called ambiguous sentences). In written Dutch, these sentences can also be disambiguated at an earlier point, namely at the NP *the squatter*. When this noun phrase is followed by a comma, this excludes the possibility that the sentence will be resolved as an NP-coordination (for details see below). For the auditory domain, one could hypothesize that a prosodic break after the noun phrase *the squatter* has the same disambiguating function as the comma in the visual domain. It should be noted that this hypothesis does not imply that syntax and prosody are isomorphic. Not all aspects of syntax are expressed in the prosodic structure, and identical syntactic structures can lead to different prosodic utterances (see Shattuck-Hufnagel & Turk, 1996 for a review).

The combination of the modality manipulation with this ambiguity allows us to test whether readers and listeners are able to use the information contained in a comma or a prosodic break as a means of an early disambiguation, that is, a disambiguation at a point in time at which the lexical element that disambiguates the sentence (i.e., the prepositional phrase *in front of the statue* versus the verb *interrupted*) has not yet been processed. Furthermore, it allows us to test whether comma and prosodic break have a parallel function in the visual and auditory modality, respectively. Such a parallel function of a prosodic break and a comma could be because the processing of a comma is mediated through prosodic processing as suggested in the implicit prosody hypothesis (see Fodor, 2002). Alternatively, such a parallel function could be because a prosodic break and a comma are processed differently, while nevertheless having the same consequence for the disambiguation of the sentence.

An example of the Dutch materials in the visual domain is given in (3) and (4) (literal English translation is given in italics). The sentences only differ with respect to the absence (3) or the presence (4) of a comma after the NP 'de boer' (*the farmer*). Sentence (3) is ambiguous until the disambiguating verb. Sentence (4), by contrast, is disambiguated by the comma following 'de boer' (*the farmer*). Both sentences are lexically disambiguated as S-coordinations on the verb 'verdedigde' (*defended*).

(3) De sheriff beschermde de boer en de knecht verdedigde dapper de ranch tegen Johnson's bende.
The sheriff protected the farmer and the farm hand defended bravely the ranch against Johnson's gang.
(4) De sheriff beschermde de boer, en de knecht verdedigde dapper de ranch tegen Johnson's bende.
The sheriff protected the farmer, and the farm hand defended bravely the ranch against Johnson's gang.

The present study builds on a previous study on the coordination ambiguity in Dutch by Hoeks, Vonk, and Schriefers (2002). In a reading study, they compared temporarily ambiguous S-coordination sentences as in (3) (comma absent) with unambiguous S-coordinated control sentences as in (4) (comma present). In Dutch, there are no strict rules regarding the placement of a comma in S-coordinated sentences (Geerts et al., 1984; Renkema, 2004). There is, however, a general habit of not putting commas before *and* in conjoined sentences (Sanders & Metselaar, 2000, p. 163 – 164), and it is definitely not acceptable to place a comma in cases where two NPs are conjoined. So the absence of a

comma does not provide much useful information regarding the structure of a sentence, whereas its presence signals that an S-coordination (or a VP-coordination, for that matter) is very likely and excludes the possibility that the sentence will turn out to be an NP-coordination. The results of a self-paced reading experiment and an eye-movement experiment by Hoeks et al. (2005) showed, for sentences in isolation, that reading times in the disambiguating region (*defended*) were longer in the absence of a comma after the noun phrase *the farmer* (see (3)) than in the presence of a comma at this position (see (4)). Thus, in the absence of a comma, the sentence is initially analyzed as an NP-coordination, and this initial analysis has to be revised when reading the verb *defended*. By contrast, when a comma is present, the sentence is right away (from the comma onwards) analyzed as an S-coordination and thus no processing difficulty occurs at the verb *defended* as no reanalysis is necessary.

With respect to the potential impact of a prosodic break as an auditory analog of a comma, the starting point for the present research was the discovery of an ERP signature to intonational phrase (IPh) boundaries, here referred to as prosodic breaks. Steinhauer and colleagues (Steinhauer, 2003; Steinhauer et al., 1999; Steinhauer & Friederici, 2001) demonstrated that a prosodic break reliably elicits a positive shift, termed the Closure Positive Shift (CPS; see also Bögels et al., in press; Kerkhofs et al., 2007 (i.e., Chapter 3); Mietz et al., 2008; Toepel et al., 2007). In a first series of studies, Steinhauer et al. (1999) presented sentences with and without a prosodic break. They found that a CPS was elicited by sentences with a prosodic break relative to sentences without a prosodic break. In addition, they tested whether a prosodic break could induce garden path effects. To this aim, they constructed sentences in which the prosodic information and the syntactic information either were in line (both a prosodic break and a syntactic clause boundary were present at the same point in the sentence, or neither a prosodic break nor a syntactic clause boundary was present) or were in conflict with each other (a prosodic break was present, whereas there was no syntactic clause boundary). When the prosodic structure did not match the syntactic structure of the sentence, processing difficulty was observed at the point at which the disambiguating syntactic information (which occurred some words after the prosodic break) was encountered. With respect to the functional significance, Steinhauer and colleagues proposed that the CPS is tightly linked to the cognitive process of structuring the incoming speech signal: A CPS occurs immediately when a prosodic break is perceived and is used to guide syntactic parsing decisions[3].

In a second series of studies, Steinhauer and Friederici (2001) explored whether the CPS is a universal marker for prosodic phrasing during listening and reading. They tested whether punctuation, which also serves the role of structuring the input, gives rise to a CPS-like ERP component. Steinhauer and Friederici made the assumption that if punctuation is mediated by subvocal prosody (an "internal voice"), then its processing may resemble that of overt prosody. To test this, they presented sentences with a comma and without a comma. The main result was that a small but reliable CPS to the comma occurred for readers with strict punctuation habits but not for readers without strict punctuation habits. The difference between the two groups suggests a correspondence of punctuation habits and the impact of comma information on on-line sentence processing, which is reflected in the ERPs.

From this, Steinhauer and Friederici concluded that comma perception during reading involves processes similar to the perception of prosodic breaks in spoken language. The main difference between modalities was that the auditory CPS is larger and more extended in time than its visual counterpart. Steinhauer (2003) proposed that this difference is most likely due

[3] Recent results from Toepel, Pannekamp, and Alter (2007) suggest that a CPS is also elicited by the stress pattern of focus prosody.

to the fact that phonological representations are more strongly activated during listening than during silent reading.

Although Steinhauer and Friederici (2001) discuss the patterns at the occurrence of a comma for both lax and strong punctuation groups, they do not report the findings at the syntactically disambiguating region in detail for these two groups of participants. Therefore, it remains unclear whether the presence of a comma has different effects on how the syntactically disambiguating region of the sentence is processed by the participants with strict and with lax punctuation habits.

In the present article we combine what is known about the processing of the coordination ambiguity in the visual domain with what is known from ERP research on the processing of commas and prosodic breaks. In the visual domain, we presented sentences like (3) and (4) visually while recording the Electroencephalogram (EEG). For the auditory domain, we presented auditory versions of the same sentences with either a prosodic break or no prosodic break between the noun phrase *the farmer* and *and the farm hand,* while recording the EEG.

For the visual modality, the predictions are as follows. As described above, we know from the literature that the presence of a comma is used for the early disambiguation of these sentences towards an S-coordination analysis (Hoeks et al., 2002). A corresponding pattern should also be found in the present ERP experiment with visual stimuli. However, it should be recalled that the evidence for a CPS in response to a comma is not that general. As pointed out above, Steinhauer and colleagues only found a CPS in response to a comma for the group of readers with strict punctuation rules, but not for readers with lax punctuation rules. Because in Dutch punctuation rules are not as strict as in German, it is not clear in advance whether a CPS will be elicited by a comma in Dutch readers. This leads to the following predictions. If there is a CPS in response to the presence of a comma, we can be certain that the comma has been processed, and thus we should find a P600-effect at the disambiguating verb *defended* in the condition without a comma relative to the condition with a comma. By contrast, when there is no CPS, this could be either because the comma did not elicit a CPS, or because participants did not notice the comma. In the first instance we should find a P600-effect at the disambiguating verb *defended* in the condition without a comma relative to the condition with a comma. In the second instance we should not find any difference at the disambiguating verb.

For the auditory sentences, we expect a CPS at the prosodic break relative to the condition without a prosodic break. If the presence of a prosodic break leads the listener to adopt an S-coordination analysis right at or shortly after the prosodic break, this should in addition be reflected in the ERPs at the disambiguating verb (*defended*). More specifically, in the absence of a prosodic break, the verb *defended* will signal the need for a reanalysis of the initially preferred NP-coordination analysis while no such reanalysis would be necessary in the case of the same sentence with a prosodic break. In terms of the ERP components introduced above, we would thus expect a P600-effect in the condition without a prosodic break relative to the condition with a prosodic break. By contrast, if the presence of a prosodic break does not lead to the adoption of an S-coordination analysis right at or shortly after the prosodic break, listeners should adopt the preferred NP-coordination analysis in both conditions. In this case, there should be no differences in the ERP signatures between the two conditions (prosodic break present versus absent) at the disambiguating verb as in both conditions a reanalysis would become necessary.

In the following we will test these predictions in two ERP experiments, one in the visual domain (Experiment 1) and one in the auditory domain (Experiment 2). Both experiments were set up such that each half of the experiment comprised a complete design in order to have the possibility to track potential changes in effects over the course of experiments. This may be particularly relevant for the experiment in the visual modality given the between-

participant differences in the processing of a comma as a function of strict versus lax punctuation habits as reported in Steinhauer and Friederici (2001). As comma rules are not very strict in Dutch (see above), it could be the case that our participants may adopt strategies in the course of the experiment.

2 Results

2.1 Experiment 1: Visual modality

2.1.1 Data analysis

The data were filtered with a low-pass filter of 30 Hz. EEG and EOG records were examined for artifacts and for excessive EOG amplitude during the epochs from 150 ms preceding the onset of the NP with or without a comma (hereafter NP2, i.e., *the farmer* in (3) and (4)) and of the verb (i.e., *defended* in (3) and (4)) until 1000 ms after the respective onsets. We used a 150 ms period preceding the onset of the critical word as a baseline. Only trials in which the EOG did not exceed 75 μV, and in which no artifacts (EEG > 100 μV) occurred, were included in the analysis. The data from two participants were excluded from the analyses due to excessive artifacts, leaving the data of a total of 30 participants.

Two kinds of analysis were performed on these pre-processed data. First, we used relatively broad windows to quantify the ERP effects. Based on the 500 to 650 ms of Steinhauer and Friederici (2001, p. 277) and visual inspection of the waveforms we used the 400 to 800 ms window after NP2 onset to quantify a possible CPS at the comma. In order to quantify reflections of potential processing difficulty at the disambiguating verb, the P600 to verb onset was measured in the 600 to 900 ms window (Hagoort et al., 1999). In addition, visual inspection of the waveforms revealed a more negative going deflection from 350 to 450 ms after verb onset for the condition without a comma relative to the condition with a comma (e.g., electrodes aF7, aF3, and F3). We used the 350 to 450 ms time-window to quantify this negativity.

To further investigate the onset and duration of the effects, we performed additional time-course analyses. To this aim the average amplitude of the EEG was computed from 0 to 1000 ms in steps of 100 ms after the onset of NP2 and after the onset of the disambiguating verb. The data from these analyses are only presented if they provide additional information that is not already contained in the analyses of the broad time-windows.

The mean amplitudes of these windows were entered into a MANOVA repeated measures analysis. The multivariate approach to repeated measurements was used to avoid problems concerning sphericity (Vasey & Thayer, 1987). Two kinds of MANOVA were performed, one for the midline electrodes, and one for the lateral electrodes. The MANOVA for the midline electrodes had the factors Comma (present / absent) and Midline Electrode (aFz / Fz / Cz / Pz / Oz). The MANOVA for the lateral electrodes had Comma (present / absent) as factor, using a Hemisphere by Region of Interest (ROI) by Electrode design. The factors Hemisphere and ROI divided the scalp into 4 quadrants: left anterior (aF7, F7, aF3, and F3), right anterior (aF8, F8, aF4, and F4), left posterior (P7, PO7, P3, and PO3), and right posterior (P8, PO8, P4, and PO4).

To check whether the participants performed differently through the course of the experiment, additional analyses for the standard windows were performed which included the factor Part of Experiment (first / second half of the experiment).

2.1.2 CPS: NP2 with and without comma

Grand average waveforms time-locked to the onset of NP2 (which contains the noun with or without a comma) are presented in Figure 1. The presentation of NP2 elicited the for visual stimuli typical ERP response, that is, an N1-P2 complex. Inspection of the waveforms suggests that no CPS was elicited by the comma. For some electrodes, the Comma condition appeared to be even more negative (rather than positive) than the No Comma condition (e.g., PO8 between 550 and 600 ms and aF4 between 750 and 800 ms).

The absence of a CPS was confirmed by the statistical analysis for the CPS window (400 - 800 ms) for the midline electrodes, which did not yield an effect of Comma ($F < 1$), nor an interaction of this factor with Midline Electrode ($F < 1$). Also for the lateral electrodes neither an effect for Comma ($F < 1$) nor interactions of Comma with ROI, Hemisphere or Electrode were present (all $Fs < 1$).

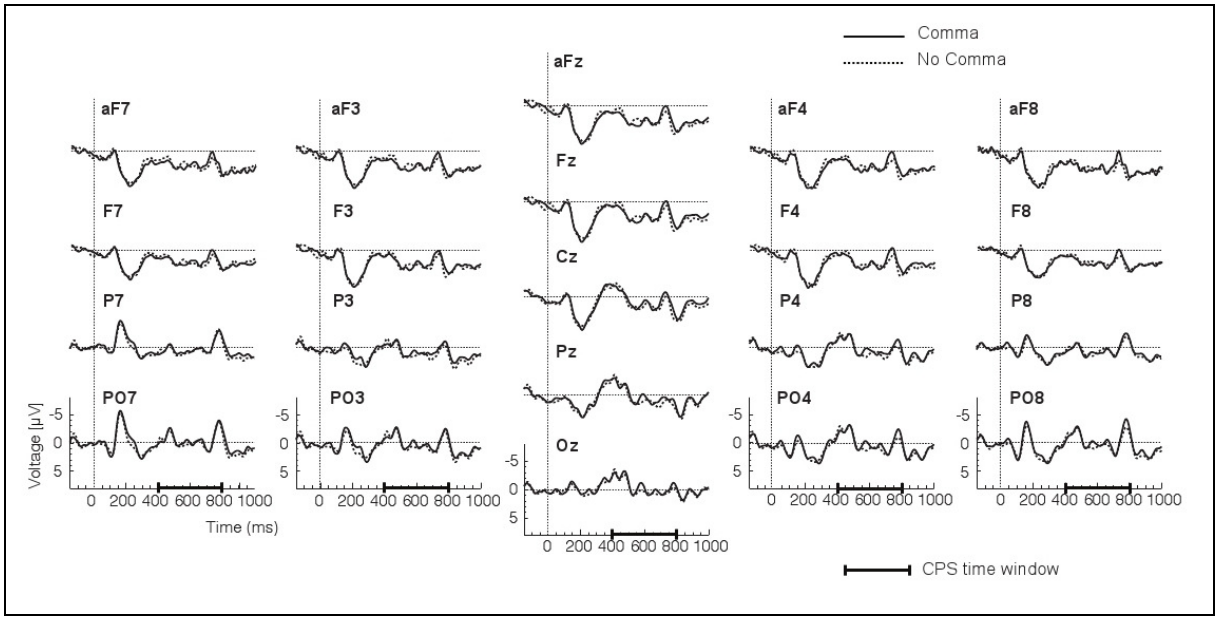


Figure 1: Grand average waveforms over participants (n = 30), time-locked to the onset of NP2, for the S-coordination sentences with a comma (solid line) and the S-coordination sentences without a comma (dotted line) in Experiment 1.

One could argue, however, that the 400 to 800 ms time-window is too long to detect a potentially small CPS. However, also the time-course analyses on consecutive epochs of 100 ms for the CPS-window did not yield reliable effects of Comma neither in the midline analyses ($Fs < 1$ for the 100 ms time-windows between 400 and 700 ms; $F[1,29] = 2.94$, $p = .096$ from 700 to 800 ms) nor in the lateral analyses ($Fs < 1$for the 100 ms time-windows between 400 and 700 ms; $F[1,29] = 3.46$, $p = .067$ from 700 to 800 ms). Furthermore, no interactions of Comma with Midline Electrode for the midline analyses were found (all $Fs < 1$). Likewise, for the lateral analyses no effects of Comma or relevant interactions were present (all $ps > .075$). Thus, there appears to be no clear and statistically reliable CPS in response to the comma. Additionally, the negative-going effects for the Comma condition described at the visual inspection were not statistically reliable. Time-course analyses on 100 ms consecutive time-windows outside the 400 to 800 ms window (i.e., the windows between 0 and 400 ms and between 800 and 1000 ms) did not show any effects of Comma, nor any interactions with this factor (all $ps > .12$).

Finally, the Part of Experiment-analyses for the midline and for the lateral electrodes also did not reveal an interaction between Part of Experiment (first versus second half of the experiment) and Comma (all ps > .20), nor any other relevant interactions (all ps > .084), indicating that the same pattern of results was found across the course of the experiment. In sum, the results of all analyses for the CPS converge in that no CPS was found in the visual modality.

2.1.3 Negativity and P600 effects: Disambiguating verb

To test for reflections of a processing difficulty at the disambiguating verb, the signals were time-locked to verb onset. Grand average waveforms are presented in Figure 2. Inspection of Figure 2 suggests the presence of a biphasic pattern for the no comma condition relative to the comma condition: a negative-going effect around 400 ms at bilateral anterior electrodes (e.g., aF3, aF4, F3, and F4) and a P600-like effect starting at about 600 ms at the midline (see aFz and Fz) and bilateral anterior sites.

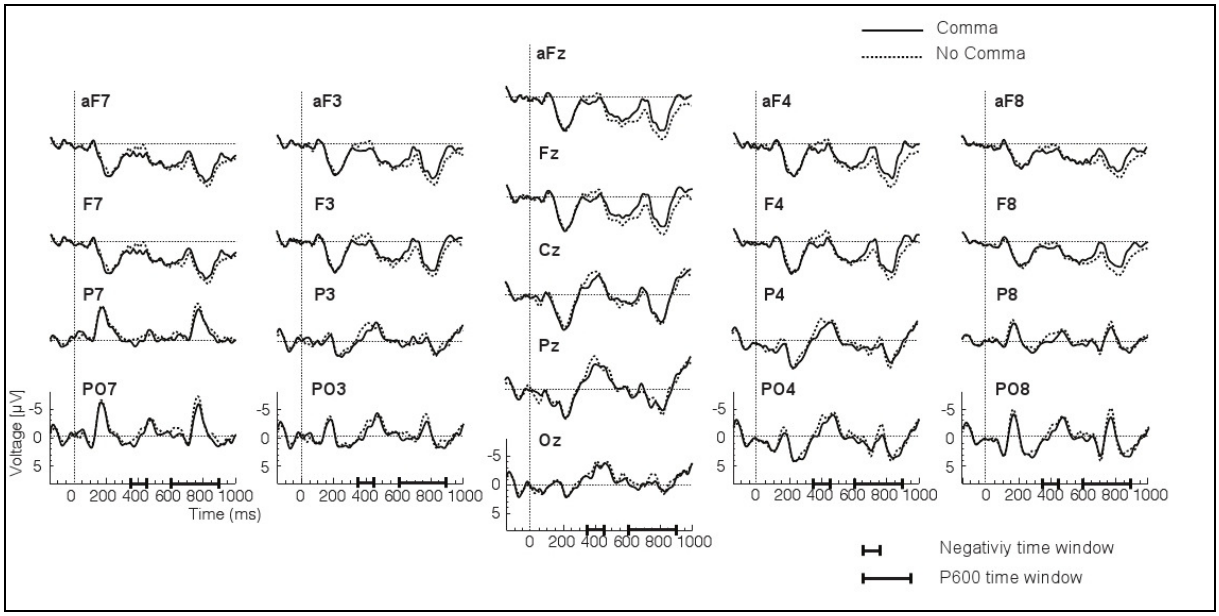


Figure 2: Grand average waveforms over participants (n = 30), time-locked to the onset of the disambiguating verb, for the S-coordination sentences with a comma (solid line) and the S-coordination sentences without a comma (dotted line) in Experiment 1.

The midline analysis for the 350 - 450 ms window did not disclose an effect of Comma (p > .10), nor an interaction between Comma and Midline Electrode (F < 1). However, in the lateral analysis an effect for Comma was obtained (F[1, 29] = 4.33; p < 05). This main effect showed that mean amplitudes were more negative-going for the sentences without a comma (i.e., ambiguous sentences) than for the sentences with a comma (i.e., unambiguous sentences). No interactions with ROI, hemisphere or electrode were found (all ps > .19), indicating that the negativity was broadly distributed across the scalp and not restricted to (left) anterior sites.

In the midline analysis for the P600 window (600 - 900 ms) no effect of Comma was obtained (p > .10). There was an interaction of Comma with Midline Electrode (F[4, 26] = 3.24; p < .05). Follow-up analyses revealed P600-like effects at two anterior sites (aFZ and Fz; both ps < .05), but not at more posterior sites (all ps > .10). The analyses for the lateral electrodes for the P600 window did not yield an effect of Comma (F < 1). Instead, an

interaction between Comma and ROI ($F[1, 29] = 9.16$; $p < .01$) was found. Separate analyses for the two levels of ROI showed an effect of Comma for the anterior ROIs ($F[1, 29] = 4.89$; $p < .05$), but not for the posterior ROIs ($p > .20$). A four-way interaction between Comma, Electrode, Hemisphere, and ROI was also present ($F[3, 27] = 3.03$; $p < .05$). Follow-up t-tests for all lateral electrodes revealed P600 effects at the following sites of the right hemisphere: aF8, aF4, and F8 (all ps < .05), and at a single site over the left hemisphere: PO7($p < .05$). The time-course analyses yielded essentially the same pattern of results as the window analyses. In sum, the analyses for the disambiguating verb indicated that a P600 effect was present at the anterior sites of both the midline and the right hemisphere.

Finally, both the midline analysis and the lateral analysis containing Part of Experiment as a factor did not yield interactions between Part of Experiment and Comma, or other relevant interactions. This indicated that the participants' brain responses to the materials remained the same during the experiments.

2.1.4 Discussion Experiment 1

In Experiment 1, no significant CPS was obtained after the comma. This is in contrast to Steinhauer and Friederici (2001), who demonstrated a CPS in response to a comma. However, Steinhauer (2003) also showed that the occurrence of a CPS in response to the presence versus absence of a comma depends on the degree to which participants did or did not follow punctuation rules (also see Introduction).

One possible explanation for the apparent discrepancy between the results of the present study and that of Steinhauer and Friederici (2001) is a difference in design. Our materials did not include any punctuation errors, while in Steinhauer and Friederici half of the critical materials and a proportion of the filler items (Experiment 1) or only a proportion of the filler items (Experiment 2) contained punctuation errors. This makes it likely that participants were more aware of the comma manipulation in Steinhauer and Friederici's experiment than in the present experiment.

The reason that we do not find a CPS in the visual modality may be that the CPS only occurs when participants' attention is focused on punctuation. Following this line of reasoning, one could argue that our data do not show a CPS because the participants were not paying particular attention to punctuation. Possibly, the participants from Steinhauer and Friederici with low punctuation knowledge also did not show a CPS because they were unaware of at least some proportion of comma errors, and thus were not as focused on punctuation as the participants with high punctuation knowledge.

A second possible explanation for the difference in results relates to the language that was tested. In Dutch, in contrast to German, language users are in general sloppy with punctuation. This could mean that our participants are similar to the participants with low punctuation knowledge from Steinhauer and Friederici (2001). It might be that these participants simply ignore the comma. However, the results at the disambiguating verb reveal that this was not the case. If the comma had not been processed at all, the unambiguous S-coordinations with a comma and the ambiguous S-coordinations without a comma should have shown identical results at the disambiguating verb. Clearly, this is not the case. The comparison of the two conditions shows a biphasic ERP pattern, that is, a negativity followed by a P600-like effect for the ambiguous S-coordinations relative to the unambiguous S-coordinations. As these two conditions only differ with respect to the presence versus absence of the comma, we can conclude that the comma must have been processed, despite the fact that it did not elicit a CPS.

Based on the timing, the negativity of the biphasic pattern at the disambiguating verb can either be an N400 or it can be a LAN. However, the scalp distribution of this effect does not match that of the LAN, which typically shows a left-anterior or anterior distribution. Instead,

the broad distribution of the effect - including posterior and anterior sites - would fit better with the distribution of an N400. Note that Steinhauer et al. (1999) in response to a prosody-syntax mismatch also observed a biphasic N400-P600 pattern.

The P600 effect in Experiment 1 did not show the centroparietal scalp distribution that is usually found in response to syntactic violations, but an anterior distribution. However, as pointed out in the introduction, previous studies on locally ambiguous sentences (as opposed to sentences with syntactic violations) have also reported an anterior scalp distribution of the P600 effect (Friederici et al., 1996; Hagoort et al., 1999; Osterhout & Holcomb, 1992; Van Berkum et al., 1999). Based on these differences in topography, some authors (Friederici et al., 2002; Hagoort et al., 1999) have proposed that the posterior distributed P600 effect indicates a failure of a parse and/or the resulting repair processes, whereas the frontally distributed P600 effect reflects processing difficulty related to revision processes in the case of (locally) ambiguous sentences. Important for our present purposes is that the finding of an anterior distributed P600 effect to locally ambiguous sentences is consistent with previous ERP studies.

2.2 Experiment 2: Auditory modality

Having established in Experiment 1 that the presence of a comma is used by readers to arrive at an early disambiguation of locally ambiguous sentences, Experiment 2 was conducted to test whether a prosodic break can have a parallel function in spoken sentence processing. The same sentences as in Experiment 1 were presented, but now in the auditory modality.

2.2.1 Data analysis

In Experiment 2 the waveforms were time-locked to the offset of NP2 (e.g., *the farmer* in (3) and (4)), and to the uniqueness point of the disambiguating verb (e.g., *defended* in (3) and (4); for details about the determination of the uniqueness point see the results section of Experiment 2 below). The data of three participants were excluded from the analyses; two due to excessive artifacts, one due to a software error, leaving the data of a total of 24 participants.

Based on visual inspection of the ERP waveforms, we used the time-window from 400 to 800 ms to quantify the CPS in the auditory modality. At first sight, this seems to contradict the time-windows used in earlier auditory CPS studies (Steinhauer, 2003; Steinhauer et al., 1999; Steinhauer & Friederici, 2001). However, it has to be pointed out that the time-locking procedure in the present study differed from that used in other auditory CPS studies. In the present study, we use the standard ERP methodology of time-locking each individual trial to a specific critical event and normalize the waveforms in a 150 ms interval directly preceding that event. For the auditory materials, we defined this critical event as the offset of the second noun (and thus the onset of the pause in the condition with a prosodic break). Previous CPS studies (Steinhauer, 2003; Steinhauer et al., 1999; Steinhauer & Friederici, 2001) time-locked and normalized the waveforms to the onset of the sentences, computing an average ERP-waveform over the entire sentences. The location of a prosodic break in the auditory signal was then determined by computing the average location of the pause of the prosodic break in the auditory signal. The latency of the CPS is estimated by comparing the point in time at which the prosodic break condition and the no prosodic break condition begin to differ with the average position of the prosodic break. Clearly, this latter procedure has the disadvantage of "considerable latency variability across trials" (Steinhauer, 2003, p. 151) with respect to the onset of the pause of the prosodic break, a problem that does not occur when time-locking the ERPs to the offset of the word preceding the pause. On the other hand, the procedure used in the present study has the disadvantage that it does not take into account potential contributions of other acoustic aspects of the prosodic break that precede the pause, such as the prefinal lengthening and pitch rise of the boundary tone. Due to these procedural

differences in time-locking and averaging, the time-windows in which a CPS is found in the present study cannot be compared directly with the time-windows from the previous studies (Steinhauer, 2003; Steinhauer et al., 1999; Steinhauer & Friederici, 2001).

Studies that use a similar time-locking procedure as in the present study also report a time-course that is similar to the time-course in the present experiment. For instance, Toepel, Pannekamp, and Alter (2007) used a similar time-locking procedure and report a CPS with a latency of 500 to 800 ms. Knösche et al. (2005) find a CPS from 500 to 600 ms in the EEG and from 400 to 700 ms in the MEG as a response to musical phrase boundaries. Finally, for the visual modality Steinhauer and Friederici (2001) investigated the CPS by time-locking to the word that either has a comma attached or has no comma attached. They report a CPS within the 550 to 650 window following comma onset. In addition to the different time-locking points for the CPS, one has to keep in mind that differences in the acoustic realizations of the prosodic break between different studies might also affect the latency of the CPS.

For the P600 at the disambiguating verb, the same window was used as in Experiment 1. In the Part of Experiment-analyses contrasting the first and the second half of the experiment, the windows for the analyses were determined by visual inspection: from 200 to 400 ms for the first half of the experiment, and from 600 to 700 ms for the second half of the experiment.

For each window, two kinds of MANOVA were performed. The midline MANOVA had the factors Prosodic Break (break / no break) and Midline Electrode (Fz / Cz / Pz). The MANOVA for the lateral electrodes had Prosodic Break (prosodic break / no prosodic break) as a factor, using a Hemisphere by Region of Interest (ROI) by Electrode design. The factors Hemisphere and ROI divided the scalp into 4 quadrants: left anterior (aF7, F7, FC3, and F3), right anterior (aF8, F8, FC4, and F4), left posterior (CP5, P7, PO7, and P3), and right posterior (CP6, P8, PO8, and P4)[4]. Also the time course analyses were carried out in the same way as for Experiment 1.

2.2.2 CPS: NP2 with and without Prosodic Break

Grand average waveforms time-locked to the offset of NP2 are presented in Figure 3. Inspection of the waveforms suggests that the prosodic break gave rise to a CPS (e.g., at CP5 and CP6). Furthermore, the CPS appears to be preceded by a negativity between 100 and 300 ms (e.g., electrodes Fz and Cz).

In the analysis for the 400 to 800 ms window for the midline electrodes, no effect of Prosodic Break ($F < 1$), and no interaction between Prosodic Break and Midline Electrode ($F < 1$) was present. Although the lateral analysis did not yield a main effect of Prosodic Break ($F < 1$), a three-way interaction between Prosodic Break, ROI, and Electrode was found ($F[3, 21]= 8.20$; $p < .01$). Separate analyses for the two levels of ROI did not yield a main effect of Prosodic Break, neither for the anterior nor for the posterior ROI (both $ps > .19$). However, for the posterior ROI a Prosodic Break by Electrode interaction was found ($F[3, 21] = 4.85$; $p < .01$). This interaction showed a trend towards significance at the anterior ROI ($F[3, 21] = 3.02$; $p = .057$). Follow-up analyses for the single sites in the posterior ROI revealed a CPS effect at bilateral centroparietal sites (CP5 and CP6; $p < .05$).

[4] Note that in Experiment 2, a different electrode montage was used than in Experiment 1. This was done because, in addition to traditional language-related areas, the auditory modality was expected to give different scalp distributions than the visual modality (see Experimental Procedure section).

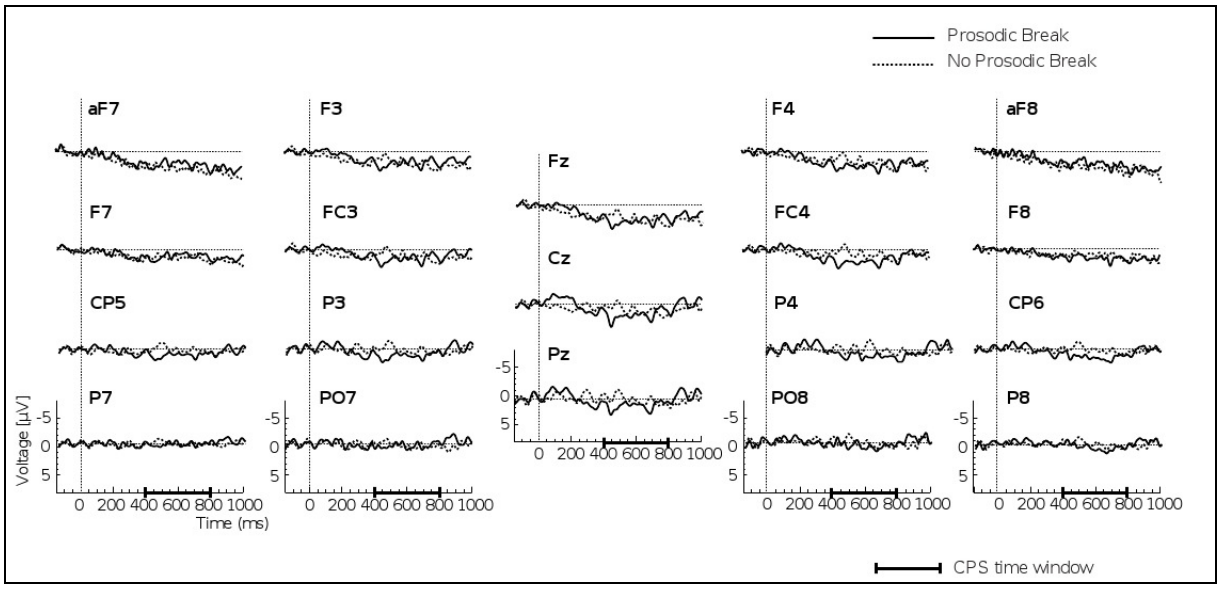


Figure 3: Grand average waveforms over participants (n = 24), time-locked to the offset of NP2, for the Prosodic Break condition (solid line) and the No Prosodic Break condition (dotted line) in Experiment 2.

The time-course analyses revealed that in the 400 to 500 ms window a CPS was obtained not only for the lateral electrodes but also for the midline electrodes. In particular, the midline analysis in this time-window yielded an effect for Prosodic Break ($F[1, 23] = 7.51$; $p < .05$). The interaction between Prosodic Break and Midline Electrode was not significant ($F < 1$) indicating that a CPS effect was broadly distributed across the midline. Likewise, the lateral analyses in the 400 to 500 ms window revealed an effect of Prosodic Break ($F[1, 23] = 5.10$; $p < .05$) and an interaction between Prosodic Break, ROI and Electrode ($F[3, 21] = 7.20$; $p < .01$). Follow-up analyses showed that a CPS effect was present at the following sites: FC3, FC4, CP5, CP6, P3 and P4 (all ps < .05). The time-course analyses thus revealed that a CPS effect was elicited at bilateral anterior and posterior sites.

With respect to the early negativity that was described in the visual inspection of the signals, the time-course analyses revealed a trend towards a significant effect of Prosodic Break for the midline analysis of the 100 to 200 ms time-window ($F[1,23]$ 3.42; $p = .078$).

The results for the midline analysis and the lateral analysis for the CPS-window containing Part of Experiment as a factor did not show any interactions between Prosodic Break and Part of Experiment (both Fs < 1) or any other relevant interactions (all ps > .091).

2.2.3 Negativity and P600 effect: Uniqueness point of the disambiguating verb

To examine the effects at the verb, averages were computed time-locked to the onset of the disambiguating phoneme of the disambiguating verb. This point was determined using the phonological representations from the CELEX database (Baayen et al., 1993). The verbs were matched against a database of words from those syntactic categories that allowed for a syntactically well-formed continuation of the sentence, but which did not lead to an S-coordination structure. The database therefore contained all plural verbs, present tense verbs, all nouns, all determiners, and all infinitives. The point of disambiguation was defined as the point at which the verb shares no more phonemes with another word in this database. The uniqueness point of the disambiguating verb was chosen for the time-locking of the averaging of the EEG signals because of the left-to-right temporal nature of the speech signal which implies that the actual verbs will be recognized at quite different points in time when using the onset of the verb as reference for time-locking. As has been pointed out by Van Berkum et

al. (2003), using the onset of a spoken word for time-locking introduces undesirable jitter in the signal (Van Berkum et al., 2003).

Grand average waveforms time-locked to the onset of the disambiguating phoneme of the verb are presented in Figure 4. Visual inspection of the waveforms suggests that no P600 effect was present.

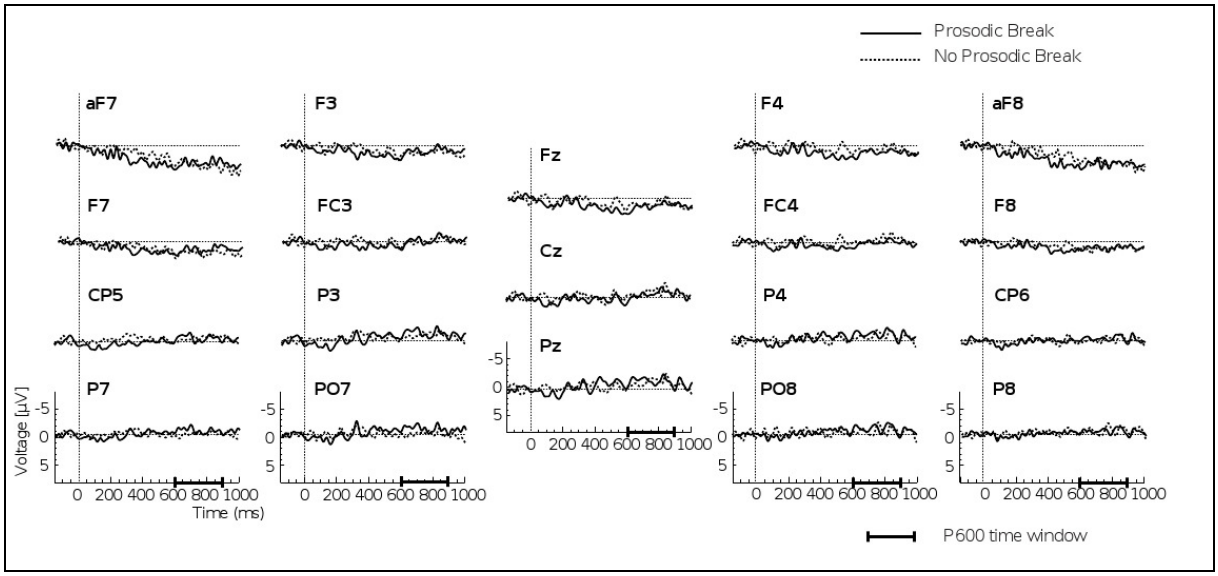


Figure 4: Grand average waveforms over participants (n = 24), time-locked to the onset of the disambiguating phoneme of the disambiguating verb, for the Prosodic Break condition (solid line) and the No Prosodic Break condition (dotted line) in Experiment 2.

Consistent with this, for the P600 window (600-900 ms) no effect of Prosodic Break (ps > .10) or relevant interactions were present neither for the midline nor for the lateral analyses (ps > .20).

Grand average waveforms, time-locked to the onset of the disambiguating phoneme of the disambiguating verb, for the first and the second half of the experiment are presented in Figures 5 and 6, respectively. Inspection of the figures suggests that the patterns for the first and the second half of the experiment differ. In the first half, a negative effect for the no prosodic break condition relative to the prosodic break condition seems to be present from about 200 to 400 ms at left anterior electrodes (e.g., aF7 and F3 in Figure 5), and between 500 and 600 ms (e.g., aF8 and F8 in Figure 5). In contrast, for the second half, a P600-like effect seemed to be present at more posterior sites (e.g., CP5, and P3 in Figure 6).

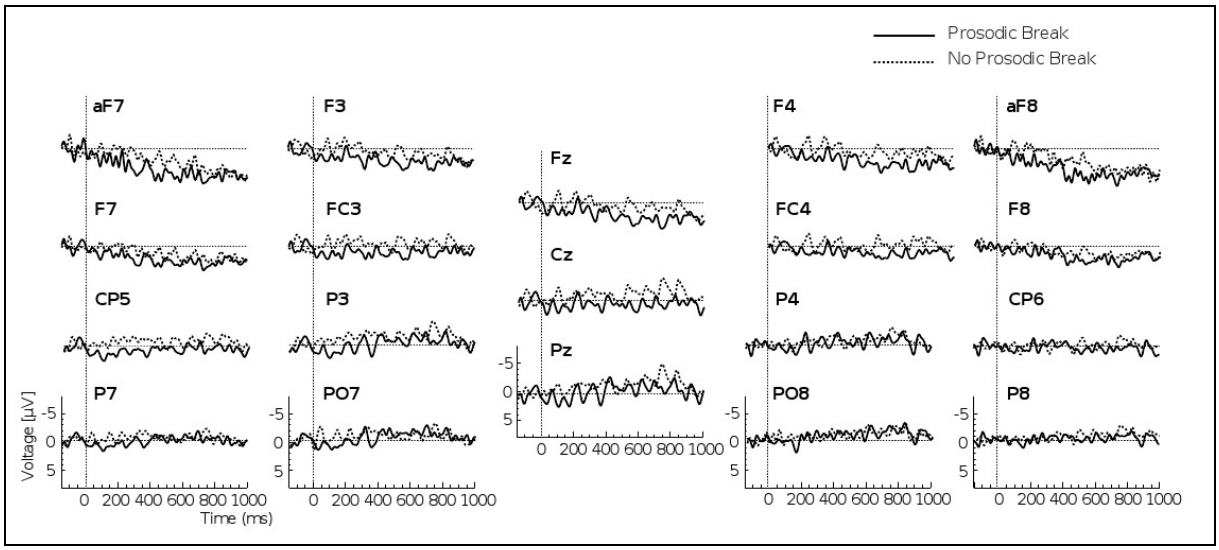


Figure 5: Grand average waveforms over participants (n = 24), time-locked to the onset of the disambiguating phoneme of the disambiguating verb, for the Prosodic Break condition (solid line) and the No Prosodic Break condition (dotted line) for the first half of the experiment in Experiment 2.

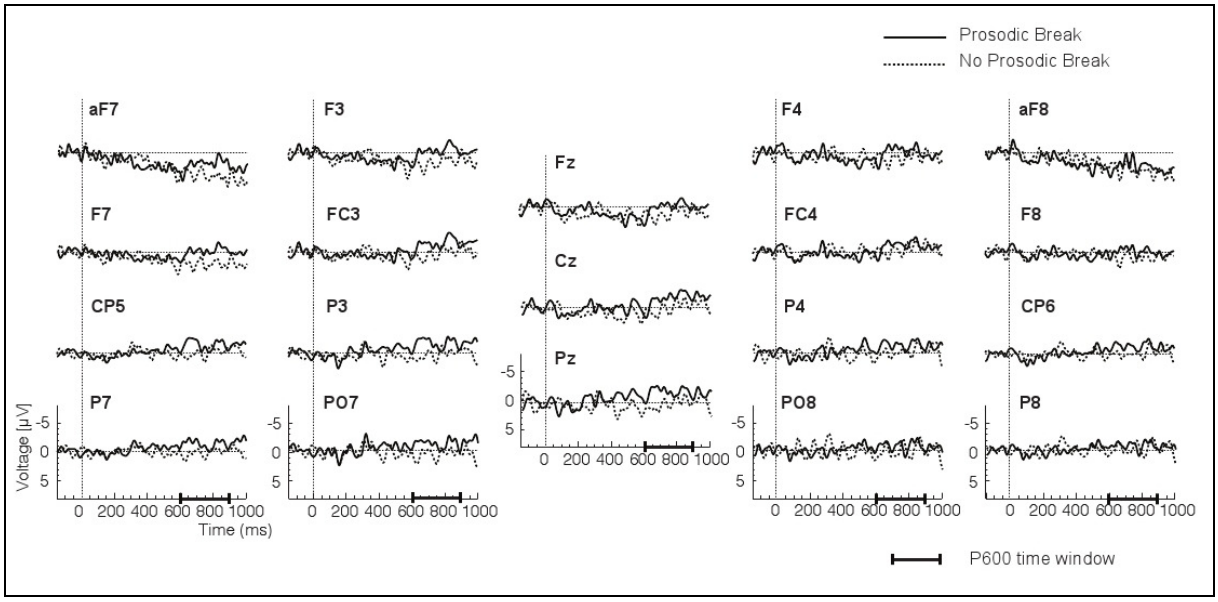


Figure 6: Grand average waveforms over participants (n = 24), time-locked to the onset of the disambiguating phoneme of the disambiguating verb, for the Prosodic Break condition (solid line) and the No Prosodic Break condition (dotted line) for the second half of the experiment in Experiment 2.

This descriptive pattern was confirmed in corresponding time-course analyses. The midline time-course analyses of the first half of the experiment for the negativity (epochs 200-300 and 300-400 ms) did not yield an effect of Prosodic Break (ps < .19) or an interaction with Midline Electrode (ps > .075). The lateral analysis for the first epoch (200 to 300 ms) yielded a main effect for Prosodic Break ($F[1, 23] = 4.37$; $p < .05$) and a Prosodic Break by Electrode interaction ($F[3, 21] = 5.59$; $p < .001$) in the absence of interactions with ROI (Fs < 1). Follow-up analyses for the single electrodes indicated that a LAN-like effect was present at the following sites: aF7, aF8, F3, FC3, and CP5 (all ps < .05). The analyses for the 300 to

400 ms window for the lateral sites yielded an interaction between Prosodic Break, Hemisphere, ROI, and Electrode ($F[3, 21] = 5.72$; $p < .01$). Follow-up analyses, however, indicated that no other effects or interactions were obtained, except for a trend towards an effect of Prosodic Break for the left-posterior ROI ($F[1, 23] = 4.16$; $p = .057$).

Further time-course analyses for 100 ms consecutive time-windows across the entire 1000 ms revealed a trend towards a main effect of Prosodic Break from 100 to 200 ms ($F[1, 23]$ 4.07; $p = .056$) in the lateral analysis. The negativity from 500 to 600 ms showed a trend towards a main effect of Prosodic Break both in the midline analysis ($F[1, 23] = 3.77$; $p = .065$) and the lateral analysis ($F[1,23] = 3.54$; $p = .073$) in the time-window 500 to 600 ms.

Statistical analyses for the second half of the experiment revealed a P600-like effect for the 600 to 700 ms epoch. Although the midline and lateral analyses did not yield effects of Prosodic Break (ps > .10) or interactions with Electrode (ps > .60), the lateral analyses did reveal a Prosodic Break by Hemisphere interaction ($F[1, 23] = 7.71$; $p < .05$). Separate analyses for the two hemispheres indicated that a P600-like effect was present for the left hemisphere ($F[1,23] = 5.91$, $p < .05$), but not for the right hemisphere ($p > .30$). The time-course analyses for the 100 ms consecutive time windows spanning the entire 1000 ms did not reveal any reliable differences between conditions (all ps > .10).

2.2.4 Discussion Experiment 2

Taken together, the data at the prosodic break replicate the findings of Steinhauer et al. (1999), and show that also for Dutch a CPS is elicited by a prosodic break. Visual inspection of the signals suggested that a small negativity preceded the CPS, but no significant effects were found. Note that other CPS-studies have also observed a small negativity preceding the CPS (e.g., Bögels et al., in press, and Kerkhofs et al., 2007 (i.e., Chapter 3)).

At the disambiguating verb, the data show a difference between the S-coordination sentences without a prosodic break and with a prosodic break. This difference indicates processing difficulty at the disambiguating verb for sentences without a prosodic break relative to sentences with a prosodic break. However, this processing difficulty took a different form in the two halves of the experiment. In the first half of the experiment, an early increase in negativity for the S-coordination sentences without a prosodic break was observed. The time course analyses revealed that this effect was significant in the 200 to 300 ms time window after the onset of the uniqueness point of the disambiguating verb. Given the timing (200-300 ms) and the anterior scalp distribution of the effect we take this effect to reflect a LAN effect. The trend towards significance in the 100 to 200 ms window does not contradict this interpretation, as this effect falls into the time window in which LAN effects for phrase structure violations have been reported (100 to 300 ms after stimulus onset). We will come back to this point in the General Discussion. In the second half of the experiment, the LAN effect disappeared and instead a P600-like effect was found for the S-coordination sentences without a prosodic break.

In order to understand the differential pattern in the two halves of the experiment at the disambiguating verb, it is useful to have a closer look at the potential functions of the presence or absence of a prosodic break. The presence of a prosodic break presumably functions in the same way as the comma in the visual modality: it signals an S-coordination. By contrast, the absence of a prosodic break may have two different functions. It may indicate the presence of an NP-coordination, or it may function as a neutral cue, i.e., it does not lead to any specific expectation of an NP- or S-Coordination.

Given these two potential functions of the absence of a prosodic break, one could hypothesize that in the first half of the experiment the absence of a prosodic break is used to predict an NP-coordination. This turns out to be correct for the experimental filler sentences (NP-coordination sentences without a prosodic break; see materials section, below), but not

for the critical S-coordination sentences without a prosodic break. Actually, for the S-coordination sentences without a prosodic break a double violation takes place. First, the expectation based on the absence of a prosodic cue is violated and second, the default NP-coordination preference is violated.

In the course of the experiment, however, listeners will learn that the absence of a prosodic break should not be taken as a reliable cue for an upcoming NP-coordination. Thus, they will treat the absence of the prosodic break as neutral (i.e., as not implying any specific upcoming syntactic structure). The standard NP-coordination preference will start to dominate, and thus syntactic processing difficulty will be reflected in a P600 effect at the disambiguating verb. Obviously, this raises the question of why a comparable pattern was not obtained in the visual domain. We will come back to this question in the General Discussion.

3 General Discussion

We presented two experiments, one in the visual and one in the auditory modality. In order to compare the two modalities, the same sentences were presented in both experiments.

In the visual study, no significant CPS occurred at the comma, but the N400/P600 effect at the verb shows that the comma has nevertheless been used to disambiguate the ambiguous S-coordination sentences. In the discussion of the visual study it was hypothesized that the absence of a CPS was due to the fact that participants did not pay specific attention to the comma. This suggests that the CPS in the visual modality does not reflect the mere detection of a comma, and thus of a syntactic break. It remains an open question as to what the CPS in the visual modality does reflect. We would suggest that it primarily reflects conscious processing of the comma. Such conscious processing can occur when part of the experimental materials contain explicit punctuation errors, as in the studies of Steinhauer (2003), Steinhauer et al. (1999), and of Steinhauer and Friederici (2001). That attention has an effect on the CPS is also consistent with a recent MEG study in the auditory modality of Knösche et al. (2005). They observed an MEG correlate of phrase structure in music perception that resembled the CPS in terms of timing and scalp distribution. Source localization suggested that structures in the limbic system, in particular, anterior and posterior cingulate as well as posterior mediotemportal cortex were the likely generator of this magnetic counterpart of the CPS. These brain structures have been shown to be involved in memory and attention processes (Cabeza & Nyberg, 2000) (for further evidence on the localization of the CPS see Ischebeck et al., 2008).

In contrast to the absence of a CPS in the visual study, Hoeks et al. *did* find a difference between NP2 with and without a comma in an eye-movement experiment in which they tested similar materials (Hoeks et al., 2005). Reading times on NP2 with a comma were slower than reading times on NP2 without a comma. These data show that the presence or absence of a comma can lead to behavioral differences, even though these differences do not show up in the ERPs.

At the disambiguating verb in the visual modality we found a negativity followed by a P600 for the sentences without a comma. Based on the broad anterior/posterior scalp distribution of the negativity it was classified as an N400. The P600 effect showed an anterior scalp distribution which has been reported before in studies using ambiguous sentences (Hagoort & Brown, 2000). The observation of a biphasic N400/P600 pattern to a prosody-syntax mismatch is in line with a previous study of Steinhauer et al. (1999).

In the auditory experiment, the prosodic break did elicit a CPS. This replicates previous findings showing that a CPS is elicited by the occurrence of a prosodic break (Bögels et al., in

press; Isel et al., 2005; Kerkhofs et al., 2007 (i.e., Chapter 3); Mietz et al., 2008; Pannekamp et al., 2005; Steinhauer, 2003; Steinhauer et al., 1999; Steinhauer & Friederici, 2001; Toepel et al., 2007). The presence of a prosodic break led to disambiguation of the S-coordination sentences: In sentences without a prosodic break reflections of a processing difficulty at the disambiguating verb were found. However, the reflections of processing difficulty in the first half of the experiment took on a different form than those in the second half of the experiment. In the first half of the experiment, we found a LAN-effect, whereas in the second half of the experiment we found a P600-effect. As described in the introduction, a LAN is associated with word category violations. If we assume that in the first half of the experiment the absence of a prosodic break is taken as a cue for an NP-coordination interpretation, the S-coordination sentences without a prosodic break contain both a violation against the default NP-coordination expectation and a violation against the additional expectation induced by the prosodic cue. This should lead to an extremely strong expectation of an NP-coordination. Therefore, the occurrence of a verb after NP3 (i.e., *defended* following the *farm hand* in (3) and (4)) will be picked up as a word category violation. This interpretation is consistent with the early timing of the LAN effect in the first half of the auditory study (200-300 ms following the uniqueness point of the disambiguating verb) which corresponds well with the time window in which LAN effects to word category violations have been observed (100-300 ms; see e.g., Friederici et al., 1996).

In the course of the auditory experiment, however, the function and use of the absence of a prosodic break might change. The sentences without a prosodic break turn out to be NP-coordination sentences in two thirds of the cases. Thus, in one third of the sentences the absence of a prosodic break is not a cue for an NP-coordination. Participants might eventually learn during the first half of the experiment that the absence of the prosodic break is not a reliable cue. If this is the case, participants will stop using the absence of a prosodic break as a cue. Once the participants have learned to ignore the absence of a prosodic break, only the default NP-coordination preference plays a role. This will result in a less extreme violation of the expectations of the participants when the verb is encountered. This violation is thus not picked up as a word category violation anymore, but rather induces a syntactic reanalysis, which will result in a P600, as observed in the second half of the experiment.

The topography of this P600 effect in the auditory study differed from that in the visual study. Specifically, the auditory P600 effect was widely distributed over the left hemisphere (including anterior and posterior sites), while in the visual study it was restricted to anterior areas. This finding is at odds with the claim that frontally distributed P600 effects are associated with processing difficulty related to the revision processes for ambiguous sentences. There is one other visual study, by Kaan and Swaab (2003), that did not find an anterior positivity for non-preferred continuations in ambiguous sentences. In this study, both non-preferred and ungrammatical continuations elicited a posterior-distributed P600 effect. Based on this study, Kaan and Swaab proposed that revision is not a sufficient condition to evoke a frontally distributed P600 effect. Future studies are needed to further determine the antecedent conditions for eliciting the frontal P600 component.

We have been proposing that the negativity in the first half of the auditory experiment reflects an extreme processing difficulty due to a double violation of the expectation of an NP-coordination. But why is there no corresponding negativity in the first half of the visual experiment? According to Dutch punctuation rules, NP-coordination sentences are written without a comma. S-coordination sentences are usually also written without a comma, but the placement of a comma after the second noun (although infrequent) disambiguates the coordination as an S-coordination. This means that the absence of a comma is a neutral cue as it can signify both an NP-coordination sentence and an S-coordination sentence. Thus, there is no double violation in the visual experiment. And therefore, the pattern does not change over

the two halves because the absence of a comma is a neutral cue right from the beginning of the experiment, and remains so throughout the experiment.

In the auditory experiment, it appears as if the same word can be picked up as an outright (word-category) violation or as a signal for a need of syntactic reanalysis, depending on how strong the syntactic expectation or preference is. This proposal is similar to related work by Kim and Osterhout who showed that one and the same violation can lead to different ERP signatures depending on the strength of a syntactic expectation. Kim and Osterhout showed that in sentences like "The meal was devouring", the semantically anomalous "devouring" elicited a P600 effect (Kim & Osterhout, 2005). Additional experiments (Kim, personal communication) showed that when the same target sentences were preceded by semantically and syntactically correct sentences with the same syntactic structure (i.e., "NP was VERB-ing"), the P600 effect was eliminated. Put differently, it appears that the strength of the expectancy of a specific syntactic structure modulates the way in which a given violation is processed.

The argumentation put forward for the different patterns of results in the first and the second half of the auditory experiment follows a similar line. In the first half of the experiment the absence of a prosodic break is taken as a strong cue for an upcoming NP-coordination, and thus the disambiguating verb (*defended* in (3) and (4)) will be picked up as a word category violation. In the second half of the experiment, the absence of a prosodic break is not taken anymore as a cue for an upcoming NP-coordination, and thus the disambiguating verb will be picked up as signaling the need for syntactic reanalysis.

The present experiments show that a CPS is elicited by a prosodic break, while a comma does not necessarily elicit a CPS. Why was a CPS elicited by a prosodic break in Experiment 2, whereas no CPS was elicited by a comma in Experiment 1? We propose that whether a CPS is elicited at a boundary marker depends on how salient this marker is. Presumably a prosodic cue is more salient than a comma (at least in a language with lax punctuation rules like Dutch). If this is the case, it is more likely for a CPS to occur after a prosodic break than after a comma. This implies that the CPS cannot simply be the reflection of the processing of any boundary cue. Rather, in order to elicit a CPS, the boundary cue either has to be very salient as in the case of a prosodic break or, in case of a less salient cue like a comma, has to attract attention[5].

Regardless of whether a CPS was elicited at the boundary marker, both comma and prosodic break led to an early disambiguation at the comma or the prosodic break, hereby overriding the default NP-coordination preference. This establishes that comma and prosodic break have a parallel function as a boundary marker.

4 Experimental Procedure

4.1 Methods Experiment 1

4.1.1 Participants

The participants were 32 undergraduate students from the University of Nijmegen, 10 male and 22 female (aged 21 to 32, mean age 23.9). All participants were right-handed. Hand

[5] Note that this can also explain the occurrence of a CPS in hummed sentences as reported in (Mietz et al., 2008). In these sentences the structuring information (i.e., the prosodic breaks) is very salient because in these sentences the prosodic information presumably is the main type of structuring information availabe.

dominance was assessed by an abridged version of the Edinburgh Inventory (Oldfield, 1971). The participants were paid for their participation.

4.1.2 Materials

The stimulus materials consisted of 60 S-coordination sentences in two conditions, 60 NP-coordination experimental fillers (see Appendix II for the S-coordination sentences and the NP-coordination sentences) and 144 other fillers. The 60 NP-coordination experimental fillers were included to have an equal number of sentences that turn out to be S-coordination sentences and sentences that turn out to be NP-coordination sentences. The other filler sentences contained a subject/object relative clause ambiguity. The S-coordination sentences either were (locally) ambiguous (as in (3) repeated here as (5a)) or were disambiguated by a comma between *the farmer* and *and* (as in (4) repeated here as (5b)). The S-coordination sentences without a comma (5a) were identical with respect to syntactic word categories to the NP-coordination experimental fillers as in (6) up to the disambiguating region (*defended* in (5a) and *on* in (6)). None of the 60 NP-coordination experimental fillers contained a comma, and thus there were no sentences in the experiment that violated Dutch punctuation rules. The S-coordination sentences were lexically disambiguated by the second verb in the sentence (*defended* in 5). The NP-coordination sentences were in principle disambiguated at the end of the sentence. However, in the construction of the NP-coordination sentences, care was taken to choose PPs following NP3 that did not fit NP3 as a continuation. For example in (6) it is unlikely that … *in front of the statue* is a PP modifying the NP *the policeman*, but rather provides the location of the entire scene. As a result our NP-coordination sentences were disambiguated at the PP following NP3 (*in front of the statue* in 6). Note that the actual lexical disambiguation point for NP-coordinations is not critical for our data as the NP-coordinations only served as filler materials.

(5) a.	De sheriff	beschermde	de boer	en	de knecht	verdedigde
	The sheriff	*protected*	*the farmer*	*and*	*the farm hand*	*defended*
	NP1	verb1	NP2	and	NP3	Verb2
	dapper	de ranch	tegen Johnson's bende.			
	bravely	*the ranch*	*against Johnson's gang.*			
	Adverb	NP	PP			
(5) b.	De sheriff	beschermde	de boer,	en	de knecht	verdedigde
	The sheriff	*protected*	*the farmer,*	*and*	*the farm hand*	*defended*
	NP1	verb1	NP2,	and	NP3	Verb2
	dapper	de ranch	tegen Johnson's bende.			
	bravely	*the ranch*	*against Johnson's gang.*			
	Adverb	NP	PP			
(6)	De journalist	interviewde	de kraker	en	de agent	voor het standbeeld
	The reporter	*interviewed*	*the squatter*	*and*	*the policeman*	*in front of the statue*
	NP1	verb1	NP2	and	NP3	PP
	in het centrum van de stad.					
	in the centre of the city.					
	PP					

In addition to these materials, 20 sentences for a training block and 12 starter sentences were constructed. These sentences were representative of the materials that were used in the actual experiment. The sentences were pre-tested in a self-paced reading experiment. The data confirmed that the comma disambiguated the S-coordination sentences as reflected by a processing difficulty at the disambiguating verb in (5a) relative to (5b).

4.1.3 Design

The 60 experimental sentences (S-coordination sentences with and without a comma), 60 experimental filler sentences (NP-coordination sentences), the 144 other filler sentences, and 12 starter sentences, 276 in total, were divided into 6 blocks of 46 items. The actual design of the experiment only concerns the 60 S-coordination sentences, with the experimental factor Comma (present / absent). A pseudo-random order of all 276 items was generated, such that the maximum number of S-coordination sentences in a row was 3. Furthermore, each block started with 2 starter sentences. We constructed two versions of this order, such that each version contained 30 S-coordination sentences without a comma and 30 S-coordination sentences with a comma. Within each version, each of the 60 S-coordination sentences occurred only once. Half of the participants read version one and the other half read version two. Therefore, across participants, each S-coordination sentence contributed to each of the two levels of the experimental factor Comma equally often, but each participant saw each S-coordination sentence in only one of the two conditions. Furthermore, the pseudo-random order was constructed in such a way that the first and the second half of the experiment also followed these constraints. Thus each of the two halves also comprised a complete design. The 20 training sentences were combined into a training block. Also for this block the list was generated in a pseudo-random fashion, such that the maximum number of S-coordination sentences in a row was 3.

4.1.4 Apparatus

The EEG was recorded from 27 tin electrodes mounted in an elastic electrode cap. Of these 27 electrodes, 21 were included in the analyses (see paragraph 2.1.1). The electrode positions were a subset of the international 10% system which has been used in other studies on sentence processing in the visual modality (e.g., Van Herten et al., 2005). The left mastoid served as reference during the recording, but before the EEG was analyzed, the signal was re-referenced to software linked mastoids. Electrode impedance was less than 3 KΩ. Vertical EOG was recorded bipolary by placing electrodes above and below the right eye. Horizontal EOG was recorded bipolary by placing electrodes beside the left and beside the right eye. The electrode impedance of the EOG electrodes was less than 5 KΩ. EEG and EOG channels were amplified (time constant = 10 s, bandpass = .02 - 100 Hz). All signals were digitized on-line with a sampling frequency of 500 Hz using a 16-bit A/D converter.

4.1.5 Procedure

The participants were tested in a soundproof and dimly lit room. The sentences were presented using Rapid Serial Visual Presentation (RSVP), centered (with a fixed left margin) on a computer screen. Each word of the sentence was presented separately for 300 ms, followed by 300 ms of blank screen, before the next word appeared. In the case of very short words (like articles or prepositions), an entire constituent or a part of a constituent was shown (e.g., [de ranch] (*the ranch)* and [tegen Johnson's bende.] (*against Johnson's gang.*) in example (7)). The comma was presented together with NP2 (e.g., [de boer,] (*the farmer,*) in (7)).

(7) [De sheriff] [beschermde] [de boer] [en] [de knecht] [verdedigde] [dapper] [de ranch] [tegen Johnson's bende.]

A trial started with the presentation of a fixation cross in the center of the screen for 300 ms. The first word of the sentence was presented 600 ms after the onset of the fixation cross. The participants were asked not to blink while reading a sentence. In order to determine whether participants were paying attention to the sentences, 20 % of all sentences (experimental and all filler sentences) were followed by a question. For instance, the question for the sentence in (3) was: "Did the farmer defend the ranch?", for which the "no" answer would have been appropriate. Before each question, the word "VRAAG" (*question*) was presented in upper case. Participants had to answer the question by pressing a button on a button box with the right index finger ("yes" response) or the left index finger ("no" response)[6]. After 1500 ms following the offset of the last word of a preceding trial, or following the button press after a question, the fixation cross for the next trial appeared.

4.2 Methods Experiment 2

4.2.1 Participants

The participants were 27 undergraduate students from the University of Nijmegen, eight male and 19 female (aged 19 to 28, mean age 22.8) who fulfilled the same criteria as those in Experiment 1 and had not participated in Experiment 1.

4.2.2 Materials

The materials used for the recording session were constructed as follows. For each S-coordination sentence used in the visual ERP study (e.g., example (5) repeated here as (8)), a second sentence was constructed with an NP-coordination structure (e.g., example (9)). This was accomplished by modifying the S-coordination sentences by replacing the Verb Phrase of the S-coordination sentences (from "*defended"* to the end of the sentence in (8)) with two or more Prepositional Phrases (PPs; *in front of the shed* in (9)). This resulted in 60 NP-coordination experimental fillers which were identical to their S-coordination counterparts up to the second verb (*defended*), or PP (*in front of the shed*). In addition, the same 60 NP-coordination experimental filler sentences, 144 unrelated filler sentences, 14 training block items, and 12 starter items were used as in Experiment 1.

(8) De sheriff beschermde de boer en de knecht verdedigde dapper de ranch tegen Johnson's bende.
The sheriff protected the farmer and the farm hand defended bravely the ranch against Johnson's gang.

(9) De sheriff beschermde de boer en de knecht voor de schuur waar een gevecht plaatsvond.
The sheriff protected the farmer and the farm hand in front of the shed where a fight was fought.

A female speaker recorded these materials. The speaker was instructed to first read the sentences for herself, and then to read the sentences out loud. She was asked to produce the NP-coordination sentences twice with a clear continuation intonation (without a prosodic break), and to produce the S-coordination sentences four times, twice with a prosodic break

[6]Only 6.5 % of the questions was answered incorrectly, indicating that the participants had been paying attention to the meaning of the sentences.

after *farmer*, and twice with as little prosodic marking as possible (neutral). The materials were recorded in blocks of ten items in a row, alternating between 10 S-coordination items and 10 NP-coordination items. This resulted in 2*60 S-coordination sentences with a prosodic break, 2*60 S-coordination sentences with a neutral intonation, 2*60 modified to NP-coordination sentences (such as (9)) with an NP-coordination intonation, 2*60 NP-coordination experimental fillers, 144 unrelated filler sentences containing a subject relative / object relative clause ambiguity, 14 training block items, and 12 starter items.

From these recorded materials, the experimental sentences and filler sentences were constructed as follows. First, from the two recordings of the same sentence the second recording was discarded, except when the first had an artifact in it (e.g., a cough from the speaker). Second, for the experimental S-coordination sentences, the neutral intonation S-coordination sentences were duplicated, creating a set of two identical sentences with neutral intonation. Finally, for each of these two duplicates, a first target sentence was constructed by cross-splicing the coordination part (*the farmer and the farm hand*) from sentences such as (8) over the coordination part in the first neutral sentence. A second target sentence was constructed by cross-splicing the coordination part from sentences such as (9) over the coordination part in the neutral sentence. This resulted in pairs of S-coordination target sentences with the two sentences of a pair only differing with respect to the intonation in the coordination part (prosodic break present versus prosodic break absent). Like in the visual experiment, the NP-coordination experimental fillers did not contain a boundary marker (prosodic break).

The prosodic structure of the constructed target sentences was transcribed by two independent judges using the ToDI system (Gussenhoven, 2004) (see ToDI line in Figure 7). Acoustic analyses of the target sentences showed clear differences between the Prosodic Break and the No Prosodic Break conditions. The pattern from Figure 7, panel A (the prosodic break condition) consists of a pitch accent without a low target (H*) followed by a high boundary tone (%H), a pause, a low boundary tone (%L) and a pitch accent on the third noun (H*L). This pattern occurred in 65% of the sentences with a prosodic break. In addition to this pattern, a pattern in which the first pitch accent preceding the pause had a low target was observed in 35% of the sentences with a prosodic break (as denoted by the H*L in H*L %H %L H*L). The average length of the pause was 343 ms (sd: 59 ms; min: 216 ms; max 499 ms).

In the No Prosodic Break condition (Figure 7, panel B), these features were not present. Instead there were pitch accents (H*L) on NP2 (*farmer*) and NP3 (i.e., the third noun phrase: *farm hand*). The pattern from Figure 1 Panel B was observed in 82% of the sentences without a prosodic break. In addition to this structure, instances in which the second pitch accent was smaller than the first pitch accent (as denoted by !H*L in H*L !H*L) occurred in 15% of the sentences without a prosodic break. Finally in 3% of the sentences without a prosodic break, the pitch accent on the first of the two NPs was lower than the pitch accent on the second NP (!H*L H*L).

In summary, these analyses reveal clear differences between the two prosodic conditions: The prosodic break items all had a pause that was preceded by a boundary tone, the no prosodic break items contained a pitch accent on each noun, but did not contain boundary tones or a pause.

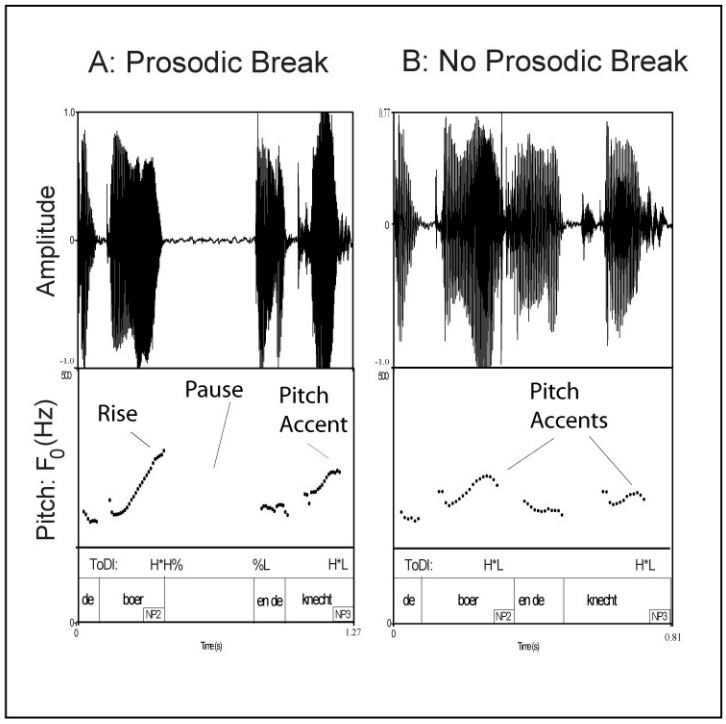


Figure 7: Acoustic properties of a typical critical region of the target sentence. The upper boxes show the amplitude of the speech signal in the Prosodic Break condition (Panel A) and in the No Prosodic Break condition (Panel B). The middle boxes show the pitch-track of the speech signal in both conditions. The lower boxes show the transcription in ToDI (Gussenhoven, 2004) and in words of the speech signal.

4.2.3 Design

Apart from the main experimental factor, the design was identical to that of Experiment 1. The main experimental factor was Prosodic Break (prosodic break / no prosodic break). The same two versions as in Experiment 1 were used.

4.2.4 Apparatus

The apparatus was the same as in Experiment 1 with two exceptions. First, we used a somewhat different electrode montage, as used earlier in auditory ERP studies (e.g., Steinhauer, 2003). The auditory cap featured 25 electrodes, of which 19 were included in the analyses (see paragraph 2.2.1). The electrode positions were a subset of electrodes from the 10% system featuring electrodes over traditional language-related sites. In addition the electrode cap for the visual modality featured more electrodes over the visual cortex, whereas the cap for the auditory modality featured more electrodes over the temporal lobes. Second, the time constant of the amplifier in Experiment 2 was 8 s instead of 10 s in Experiment 1.

4.2.5 Procedure

The participants were tested in a soundproof room. The sentences were presented over headphones. A trial started with a warning beep of 100 ms. The auditory presentation of a sentence started 500 ms after offset of the warning beep. Following the offset of each sentence there was a 4000 ms interval before the onset of the warning beep of the next trial. Because eye movements distort the EEG-signal, the participants were asked to look at a

fixation point. They were trained to avoid eye-blinks during the presentation of the items during a training block of 14 items that preceded the actual experiment. The participants were instructed to listen carefully to each story. In contrast to Experiment 1 they were not given an additional task. We did not use an additional task because we assume that the auditory materials are salient enough to ensure processing (see also Van Berkum et al., 2003).

Chapter 3: Discourse, Syntax, and Prosody: The brain reveals an immediate interaction[1]

Abstract

Speech is structured into parts by syntactic and prosodic breaks. In locally syntactic ambiguous sentences, the detection of a syntactic break necessarily follows detection of a corresponding prosodic break, making an investigation of the immediate interplay of syntactic and prosodic information impossible when studying sentences in isolation. This problem can be solved, however, by embedding sentences in a discourse context that induces the expectation of either the presence or the absence of a syntactic break right at a prosodic break. Event-Related Potentials (ERPs) to acoustically identical sentences in these different contexts were compared. We found in two experiments that the Closure Positive Shift (CPS), an ERP component known to be elicited by prosodic breaks, was reduced in size when a prosodic break was aligned with a syntactic break. These results establish that the brain matches prosodic information against syntactic information immediately.

1 Introduction

The way a sentence is understood depends on the meaning of its words, its syntactic structure, its prosody and the discourse in which it is embedded. Even in very simple sentences, syntactic word-order rules play a critical role: "John hit Jack" describes a different event from "Jack hit John". Furthermore, the prosody of a sentence can change its interpretation completely: a rising pitch on "John" in "Jack hit John" transforms the global interpretation from a statement to a question (Van Petten & Bloom, 1999). However, in contrast to this sentence-level prosody, very little is known about how prosody interacts with syntax on a local level (cf. Cutler et al., 1997). In the present article we focus on the question whether prosodic information is matched against syntactic information right at the point at which the critical prosodic information becomes available.

To address this question we use locally ambiguous sentences that allow for two different syntactic analyses up to a certain point in the sentence after which the sentence becomes disambiguated by a lexical element. For example, in sentences like (1) and (2), the sentences are ambiguous up to and including the noun phrase *the policeman*, and they are disambiguated at the word following this noun phrase. In (1), the prepositional phrase *on the square* indicates that the coordinated noun phrase *the squatter and the policeman* is the object of the verb *interviewed* (noun phrase coordination; NP-coordination), while in (2), the verb *interrupted* indicates that *the policeman* is the subject of a new sentence (sentence coordination; S-coordination). In (1), *the squatter and the policeman* form one constituent, in (2), there is a syntactic break between *the squatter* and *and the policeman*, *the policeman* being the first noun phrase of the clause *the policeman interrupted the interview right away*.

[1] This chapter, without the supplementary analyses, has been published as: Kerkhofs, R., Vonk, W., Schriefers, H., & Chwilla, D. J. (2007). Discourse, syntax, and prosody: The brain reveals an immediate interaction. *Journal of Cognitive Neuroscience*, *19*, 1421 – 1434.

(1) The reporter interviewed the squatter and the policeman on the square in front of the statue.
(2) The reporter interviewed the squatter and the policeman interrupted the interview right away.

In the present paper, we study the processing of the Dutch equivalents of these locally ambiguous (henceforth called ambiguous) sentences. In written Dutch, these sentences can also be disambiguated at an earlier point, namely at *the squatter* by means of a comma. In Dutch it is not acceptable to place a comma in cases where two NPs are conjoined. So, a comma following *the squatter* disambiguates the sentence as an S-coordination. The Dutch language provides no strict rules regarding the placement of a comma in S-coordinated sentences (see Geerts et al., 1984). There is, however, a general habit of not putting commas before *and* in conjoined sentences (Renkema, 2004, pp 163 – 164). Thus, the absence of a comma does not provide much useful information regarding the structure of a sentence, whereas its presence signals that an S-coordination (or a VP-coordination, for that matter) is very likely and excludes the possibility that the sentence will turn out to be a simple NP-coordination. For the auditory domain one could hypothesize that a prosodic break after *the squatter* has the same disambiguating function as the comma in the visual domain.

Previous research in the visual domain using offline and online measures, in particular reading times and eye tracking, has shown that readers are initially inclined to interpret the ambiguous NP (*the policeman*) as part of the NP-coordination *the squatter and the policeman* (Frazier, 1987; Hoeks et al. 2005). This is reflected in processing difficulty in S-coordinated sentences at or right after the disambiguating lexical element. Hoeks et al. compared temporarily ambiguous S-coordination sentences as in (3) with unambiguous S-coordinated control sentences as in (4) (literal English translation is given in italics). Note that the only difference between sentence (3) and (4) concerns the presence or absence of a comma following *farmer*. The results of a self-paced reading experiment and an eye-movement experiment showed for sentences in isolation that reading times in the disambiguating region (*defended*) were longer in the absence of a comma after *farmer* (as in (3)) than in the presence of a comma at this position (as in (4)). Thus in the absence of a comma, the sentence is initially analyzed as an NP-coordination. This initial analysis has to be revised when encountering *defended*. By contrast, when a comma is present, the sentence is right away (from the comma onwards) analyzed as an S-coordination and thus no processing difficulty occurs at the verb, as no reanalysis is necessary.

(3) De sheriff beschermde de boer en de knecht verdedigde dapper de ranch tegen Johnson's bende.
The sheriff protected the farmer and the farm hand defended bravely the ranch against Johnson's gang.
(4) De sheriff beschermde de boer, en de knecht verdedigde dapper de ranch tegen Johnson's bende.
The sheriff protected the farmer, and the farm hand defended bravely the ranch against Johnson's gang.

With respect to the potential impact of a prosodic break as an auditory analogue of a comma, the starting point for the present research was the discovery of an ERP signature that is elicited by intonational phrase (IPh) boundaries, here referred to as prosodic breaks. Steinhauer et al. (1999) demonstrated that prosodic breaks reliably elicit a positive shift, termed the Closure Positive Shift (CPS), with a maximal centroparietal distribution. Steinhauer (2003) has shown that the CPS is not attributable to the pause of the prosodic break alone. Sentences in which the pause was deleted still elicited a CPS. Thus it appears that the CPS can be elicited by other ingredients of the prosodic break like the boundary tone on the last syllable preceding the pause (Steinhauer, 2003).

Steinhauer and Friederici (2001) have found that a CPS is also elicited in delexicalized sentences (i.e., sentences with only the prosodic contour of spoken sentences but without any lexical and phonological content). In addition, Pannekamp et al. (2005) reported that a CPS is

elicited by a prosodic break in normal sentences, sentences without any semantic content (jabberwocky sentences), and in sentences without any semantic or syntactic content (pseudo-sentences). These results strongly suggest that the CPS is a prosody-induced ERP-component (see also Steinhauer, 2003 for further discussion).

A CPS-like component has also been observed in the area of music processing. Knösche et al. (2005) presented listeners with musical phrases containing breaks while measuring their electroencephalogram (EEG) and magneto encephalogram (MEG). The results showed a positive deflection around 500 to 600 ms for EEG, and around 400 to 700 ms for MEG. Source localization of the MEG signals showed that the effects originated from the anterior and posterior cingulates, areas that are also linked to memory and attention.

Earlier studies showed that prosodic information can be used to disambiguate lexical ambiguities and sentence-level ambiguities. Salverda et al. (2003) showed that the length of a syllable can be used to discriminate between monosyllabbic words (e.g., *ham*), and words that have the monosyllabic word as a first syllable (e.g., *hamster*). They performed a series of experiments in which they showed that the length of a syllable determined whether participants interpreted this syllable as a monosyllabic word, or as part of a larger word, irrespective of whether it originated from a monosyllabic word in isolation or an isolated first syllable of a larger word (see also Isel et al. 2003). Christophe et al. (2004) showed that a phonological boundary disambiguated continuity versus break ambiguities on the word level (e.g., in *un chat grincheaux* [a grumpy cat] the underlined part has the competitor *chagrin* [sorrow]). Shorter reaction times were measured in a word monitoring task and in a phoneme monitoring task when there was a phonological boundary present between *chat* and *grincheaux*, than when no such boundary was present, showing that the availability of prosodic information decreases the number of lexical candidates activated at any moment in time, resulting in faster and more efficient lexical access (see also Christophe et al. 2003).

There is also evidence that sentence-level prosody can interact with syntax. For instance, listeners can determine major syntactic breaks in delexicalized sentences or hummed sentences, based on prosody alone (e.g., Collier & 't Hart, 1975; see Cutler et al. (1997) for an extensive review). More recently, Eckstein and Friederici (2005) performed a series of experiments on the prosody of sentence-final words. They found that if words with a sentence-final intonation are placed in penultimate position, this mismatch between prosody and syntactic structure at the following word gave rise to an N400. They argued that the N400 on the final word reflects the increased costs to integrate this word into the context. When the final word of a sentence was marked as the penultimate word of a sentence, they reported a right-anterior negativity, which was interpreted as a reflection of purely prosodic aspects of processing. As for the CPS, a parallel can be drawn with the ERP literature on music processing. Here an early right-anterior negativity was reported (around 150 ms) following the violation of expectancies of the upcoming musical structure (See Koelsch et al., 2003). Finally, Astésano et al. (2004) showed that a prosodic mismatch (e.g., a statement that ends with a F0 pattern typical for questions) can elicit a positive deflection that peaks around 800 ms after the onset of the prosodic pattern (P800). This P800 differs in three ways from the CPS. First, the CPS is functionally linked to the processing of prosodic boundaries, while the P800 is elicited by more sentence-level prosodic contours. Second, contrary to the CPS, the P800 is a narrow peak, and, third, is left-lateralized as opposed to the centroparietal distribution of the CPS. In general, these studies on the processing of prosodic information suggest that prosody can play a disambiguating role on the word level and on the sentence level.

Prosody is also closely related to discourse structure as is evident from work on the relation between pitch accents and focus. For instance, Magne et al. 2005 presented participants with sentences that were embedded in contexts (questions) that set up

expectations for particular focus structures. The prosodic structure of these sentences were either congruous or incongruous with these expectations. The ERPs showed different responses for congruous prosodic pitch contours and incongruous prosodic pitch contours. This shows that prosodic focus patterns are processed on-line by listeners to understand the pragmatic structure of a message.

The present paper will study the processing of prosodic breaks in locally ambiguous sentences that are embedded in discourse contexts. The fact that a CPS is elicited by a prosodic break in itself does not show whether a prosodic break is being used in sentence comprehension. Therefore, Steinhauer et al. (1999) also tested whether a prosodic break could induce garden path effects. To this aim they constructed sentences in which the prosodic information and the syntactic information either were in line (both a prosodic break and a syntactic clause boundary were present at the same point in the sentence, or neither a prosodic break nor a syntactic clause boundary was present), or were in conflict with each other (a prosodic break was present, whereas there was no syntactic clause boundary). They confirmed that a CPS was elicited by the prosodic break. Furthermore, when the prosodic structure did not match the syntactic structure of the sentence, processing difficulty was observed at the point of the disambiguating syntactic information (which occurred some words after the prosodic break), as reflected in a biphasic N400-P600 pattern. With respect to the functional significance of the CPS, Steinhauer and colleagues proposed that the CPS is tightly linked to the cognitive process of structuring the incoming speech signal: A CPS occurs immediately when a prosodic break is perceived and is used to guide syntactic parsing decisions. More specifically, the parser is assumed to postulate a syntactic break at the position of the prosodic break. If this postulated syntactic break is contradicted by lexical-syntactic information at a later point in the sentence, processing difficulty will occur. The study by Steinhauer et al. shows that a prosodic break can lead to syntactic processing difficulty several words after the occurrence of a prosodic break. However, these results do not provide an answer to the question whether prosodic information and syntactic information interact *immediately* when both types of information become available.

At first sight, the demonstration of this immediate interaction appears to be an impossible enterprise. Manipulating the presence versus absence of a syntactic break at the position of a prosodic break requires the use of locally syntactic ambiguous sentences that allow for syntactic analyses with and without a syntactic break up to at least the word following the prosodic break. However, this implies that the presence or absence of a syntactic break in such locally ambiguous sentences only becomes apparent in retrospect, at the point of syntactic disambiguation (the verb *defended* in (3) and (4)), which necessarily follows the prosodic break. Consequently, the detection of a prosodic break and of a syntactic break can never occur at the same point in the sentence.

We present a solution to this impasse by embedding locally ambiguous sentences in discourse contexts, which either induce an expectation of a syntactic break at the position of the prosodic break, or do not induce such an expectation. If this context manipulation modulates the CPS to the identical spoken sentence, this would demonstrate that prosodic information is matched against the expected syntactic structure. Crucially, this context manipulation allows us to align the expectation of a syntactic break with the occurrence of a prosodic break at the same point in the spoken sentence. Only in this way is it possible to test whether the brain matches syntactic and prosodic information immediately when they become available.

To induce expectations about the syntactic structure, we made use of two principles of topic structure that have already been used by Hoeks et al. (2002) in a visual study investigating context influences on the processing of the type of sentences used in the present study. Topic-structure can be defined as describing the relation between the topic of a

sentence (the element referring to an entity about which information is given) and the new information that is expressed in a sentence (Lambrecht, 1994). Furthermore, there is a strong tendency to have topics fulfill the syntactic function of subject of the sentence (Li & Thompson, 1976).

The first principle is the principle of minimal topic structure: In the absence of explicit contextual or syntactic cues regarding the topic-structure of a sentence, assume the simplest topic-structure possible (Hoeks et al., 2002). That is, as a default, readers and listeners assume one topic in a sentence. According to Hoeks, Vonk, and Schriefers (2002) the NP-coordination preference for sentences in isolation originates from the principle of minimal topic structure. NP-coordinations have one topic (i.e., the reporter in (1), which is the subject of the verb interviewed). By contrast, S-coordinations have two topics, one for each coordinated clause (i.e., the reporter and the policeman in (2), and the sheriff and the farm hand in (3) and (4)) and thus do not comply to the preferred minimal topic structure. The second principle is topic continuity (Givón, 1983). If a discourse entity has fulfilled the topic role in previous sentences in a discourse, or was introduced as a topic, there is a preference of having that entity in the topic role in a new sentence.

To induce the expectation of an S-coordination in sentences like (3) and (4), and thus the expectation of a syntactic break between *farmer* and *and*, one can embed S-coordination sentences like (3) and (4) in a discourse (see Table 1) in which *the sheriff and the farm hand* is already introduced as one topic (see the biasing context sentence B.2 in Table 1). After the listener has heard "*The sheriff protected the farmer*" in the target sentence (sentence C from Table 1), the listener will conceive of *the sheriff* as a topic on its own. However, given the structure of the biasing context sentence, *the farm hand* wants to remain topic as well. The listener will therefore assume a syntactic structure of the target sentence that allows *the farm hand* to be topic (and thus to be in the subject position). The obvious way to accomplish this is to assume that after *the farmer* a new clause will start with *the farm hand* as the subject. This leads to the expectation of a syntactic break following *farmer*.

Table 1. Example of an experimental item used in Experiments 1 and 2, with English Translation in italics

A Lead-in sentence
Nog geen dag nadat James “Mad Dog” Johnson werd vrijgelaten uit de gevangenis was het alweer raak in Painful Gulch.
Hardly a day since James "Mad Dog" Johnson's release from prison, trouble started again in Painful Gulch.
B.1 Neutral context*
Toen Johnson zijn mannen weer opgetrommeld had, was de grootste boerderij in de buurt het doelwit van hun actie.
After Johnson summoned his men, the largest ranch in the neighborhood was targeted for their raid..
B.2 Biasing context*
Toen ze de boer om hulp hoorden roepen, snelden de sheriff en de knecht naar de boerderij.
When they heard the farmer cry for help, the sheriff and the farm hand rushed to the ranch.
C Target sentence
De sheriff beschermde de boer en de knecht verdedigde dapper de boerderij tegen Johnson’s bende.
The sheriff protected the farmer and the farm hand defended bravely the ranch against Johnson's gang..
D Exit sentence 1
Na een vuurgevecht van meer dan drie uur kwam er eindelijk versterking voor de sheriff.
After a firefight of over an hour reinforcements for the sheriff finally arrived.
E Exit sentence 2
Gelukkig kon Johnson nog dezelfde dag weer worden opgesloten.
Luckily Johnson was put behind bars again the very same day.

* In the experimental materials, either the neutral or the biasing context-sentence was presented.

These contexts biasing towards an S-coordination (henceforth called biasing contexts) are contrasted with neutral contexts that provide a general setting in which the critical sentence fits naturally, without mentioning any of the noun phrases of the coordination sentence (see the neutral context sentence B.1 in Table 1). In the case of a neutral context, the minimal topic structure principle will apply, and therefore listeners assume only one topic, which is in line

with an NP-coordination structure: the listener will not expect a syntactic break after the second noun phrase (i.e., after farmer).

The effectiveness of this context manipulation has been established in reading time studies (Hoeks et al., 2002). In the Neutral Context Condition, reading times on the disambiguating verb (e.g., defended) were longer in ambiguous S-coordination sentences such as (3) than in unambiguous S-coordination sentences such as (4), showing the default NP-coordination preference. This pattern of results changed when the sentences were embedded in a biasing context. In the Biasing Context condition, reading times for the disambiguating verb in the ambiguous (3) and unambiguous (4) S-coordinations did not differ. This shows that the biasing context successfully sets up a syntactic expectation of an S-coordination. Thus reading the disambiguating verb in S-coordination sentences without a comma, but embedded in a biasing context does not lead to processing difficulties. These results imply that in the biasing contexts readers indeed expected a syntactic break after the second noun phrase (i.e., after *farmer*).

In the present experiments we use this context manipulation to align a prosodic break between *farmer* and *and* with the expectation of a syntactic break at the same point. The experiment comprised four conditions. In the first two conditions, coordination sentences with a prosodic break were embedded in neutral and biasing contexts; in the other two conditions, coordination sentences without a prosodic break were embedded in neutral and biasing contexts. The syntactic disambiguation was always opposite to the prosodic information. That is, sentences that were disambiguated at the verb as S-coordinations did not have a prosodic break between *farmer* and *and*; sentences that were disambiguated at the prepositional phrase as NP-coordinations did have a prosodic break between the second noun phrase and *and*.

In order to demonstrate a direct match of prosodic and syntactic information, the sentences with a prosodic break in the Neutral Context condition were compared with the acoustically identical sentences in the Biasing Context condition. For the sentences with a prosodic break in the Biasing Context condition, the expectation of a syntactic break and the presence of a prosodic break coincide; in contrast, for the same sentences in the Neutral Context condition, the absence of the expectation of a syntactic break and the perceived prosodic break collide. Because the sentences within this critical comparison are the identical acoustic signals, any difference obtained at the prosodic break would demonstrate that prosodic information is immediately evaluated against the contextually induced syntactic expectation.

If prosodic information and syntactic information are matched immediately when they become available, we should see a reflection of this immediate matching in the CPS. Following the discussion above we hypothesize that the deflection of the CPS is larger when a syntactic break is not expected at the position of the prosodic break (as in the Neutral Context condition), than when a syntactic break is expected at the position of the prosodic break. A modulation of the CPS by context would demonstrate that prosodic and syntactic information are matched immediately, that is, right at the point where the information becomes available.

2 Experiment 1

2.1 Methods

2.1.1 Participants

The participants were 30 undergraduate students from the University of Nijmegen, 12 males and 18 females. The participants were between 20 and 28 years of age, with a mean age of

23.1. All were right-handed; hand dominance was assessed by an abridged version of the Edinburgh Inventory (Oldfield, 1971). The participants were paid for their participation.

2.1.2 Materials

Before we constructed the auditory stimulus materials, we created the materials that were used for the recording session in two steps. The point of departure was 60 S-coordination sentences (e.g., (4) repeated here as (5b)) and 60 NP-coordination sentences (e.g., (1) repeated here as (6a)) used in an earlier study. The S-coordination sentences are disambiguated by the second verb in the sentence (*defended* in 5b, and *interrupted* in 6b). The NP-coordination sentences are in principle disambiguated at the end of the sentence. However, in the construction of the NP-coordination sentences, care was taken to choose PPs following NP3 that did not fit NP3 for continuation. For example in (6a) it is unlikely that … *on the square* is a PP modifying the NP *the policeman*, but rather provides the location of the entire scene. As a result our NP-coordination sentences were disambiguated at the PP following NP3 (*in front of the shed* in 5a, and *on the square* in 6a).

For each of these sentences a neutral context and a (S-coordination) biasing context was constructed. This resulted in 240 (2 * 2 * 60) short stories of four to five sentences. A story consisted of a lead-in sentence, a context sentence, a target sentence, and one or two exit sentences (see Table 1; all materials are listed in Appendix III).

In order to have the speaker produce the coordination part (*the farmer and the farm hand*) of each sentence both with and without a prosodic break, a second sentence was constructed with the opposite syntactic structure for each sentence. This was accomplished by modifying the NP-coordination sentences (6a) into S-coordination sentences by replacing the prepositional phrase (PP; *on the square...* in 6a) with a verb phrase (VP; *interrupted ...* in 6b). Likewise, the S-coordination sentences (5b) were modified into NP-coordination sentences by replacing the VP (*defended ...* in (5b)) with a Prepositional Phrase (*in front of the shed...* in (5a)). This new PP (see the Dutch version in 5a) or VP (see the Dutch version in 6b) always started with the same phoneme as the old VP (as in (5b)) or PP (as in (6a)) to make later cross-splicing easier.

(5a) De sheriff beschermde [de boer en de knecht] voor de schuur waar een gevecht plaatsvond.
The sheriff protected [the farmer and the farm hand] in front of the shed where a fight was fought.
(5b) De sheriff beschermde [de boer en de knecht] verdedigde dapper de ranch tegen Johnson's bende.
The sheriff protected [the farmer and the farm] hand defended bravely the ranch against Johnson's gang.
(6a) De journalist interviewde [de kraker en de agent] op de Dam voor het standbeeld.
The reporter interviewed[the squatter and the policeman] on the square in front of the statue.
(6b) De journalist interviewde [de kraker en de agent] onderbrak het interview meteen.
The reporter interviewed [the squatter and the policeman] interrupted the interview right away.

In sum, we had 60 S-coordination sets (consisting of the S-coordination sentence in a biasing and in a neutral context, plus the corresponding adapted-to-NP-coordination sentence) and 60 NP-coordination sets (consisting of the NP-coordination sentence in a biasing and in a neutral context, plus the corresponding adapted-to-S-coordination sentence). In addition to these experimental items, six starter items, and 14 training items were created.

A female speaker recorded these materials. For each set the speaker recorded the neutral context with its coordination sentence once, the biasing context with its coordination sentence once, and the adapted sentence twice. The speaker, a student of Dutch who was knowledgeable on Dutch prosody, was instructed to first read the sentences for herself, and then to read the sentences out loud. She was asked to produce a prosodic break after the second noun phrase (NP2) in the S-coordination sentences, and to avoid a break after NP2 in the NP-coordination sentences. The materials were recorded in blocks of ten sets in a row,

alternating between ten S-coordination sets and ten NP-coordination sets. This resulted in 60 S-coordination sentences with a prosodic break embedded in a neutral context, 60 S-coordination sentences with a prosodic break embedded in a biasing context, 60 NP-coordination sentences without a prosodic break embedded in a neutral context, 60 NP-coordination sentences without a prosodic break embedded in a biasing context, two times 60 modified-to-NP-coordination sentences without a prosodic break, and finally, two times 60 modified-to-S-coordination sentences with a prosodic break.

From these recorded materials, the actual stimulus materials were constructed as follows. First, for each adapted sentence pair, the second sentence was discarded, except when the first had an artifact in it (e.g., a cough). Second, for each set one target sentence was constructed by cross-splicing the segment between brackets from sentence (5a) over the segment between brackets in sentence (5b). The same cross-splicing was applied to (6b) and (6a). Note that the segments between brackets in (5a) and (5b) and in (6b) and (6a) are the same, except for their prosodic structure. This resulted in a target sentence in which the intonation was opposite to the syntactic disambiguation of the sentence. Third, half the neutral context tokens and half the biasing context tokens were duplicated, resulting in two identical tokens which were used as the basic frame to construct the final items. For each identical token pair, the cross-spliced target sentence was spliced in. This resulted in 120 pairs (60 S-coordination and 60 NP-coordination pairs) of identical stories. Finally, the entire context sentence from the non-duplicated story was cross-spliced over the context sentence in one of the two copies. This resulted in stories in which the neutral and the biasing context only differed from each other with respect to the context sentences; the rest of the signal was acoustically identical. Therefore, any differences found between the two context conditions cannot be due to acoustic differences in the materials.

Table 2 shows the complete design of both Experiment 1 and Experiment 2. A full design with a complete crossing of the factors Context (neutral vs. biasing), Sentence Type (S-coordination vs. NP-coordination), and Prosodic Structure (Prosodic Break vs. No Prosodic Break) would have led to an experiment that would have been too long. As can be seen in Table 2, the S-coordination sentences in Experiment 1 do not have a prosodic break, while the NP-coordination sentences do have a prosodic break. By contrast, in Experiment 2 the situation was reversed such that the S-coordination sentences had a prosodic break, and the NP-coordination sentences did not. Within each experiment the S-coordination sentences were acoustically identical across context conditions, as were the NP-coordination sentences. The sentences without a prosodic break in the Biasing Context condition were included as a filler condition to balance the possible combinations of context and prosodic structure, so that the neutral context and the biasing context are followed by both a prosodic break and no prosodic break[2].

[2] This condition also allowed us a first exploration whether the absence of a prosodic break is a prosodic cue that can interact with syntactic expectations. Although some subtle differences were found between the no prosodic break conditions in neutral context and in biasing context, the results were inconclusive. See Supplementary Analyses II for further details.

Table 2: Design of the experiments

Experiment	Prosodic break	Context	Lexically disambiguated as
Experiment 1	Yes	Neutral	NP-coordination
	Yes	Biasing	NP-coordination
	No	Neutral	S-coordination
	No[a]	Biasing[a]	S-coordination
Experiment 2	Yes	Neutral	S-coordination
	Yes	Biasing	S-coordination
	No	Neutral	NP-coordination
	No[a]	Biasing[a]	NP-coordination

[a] Condition was included as a filler condition (see text).

The acoustic analyses of the target sentences showed clear differences between the Prosodic Break and the No Prosodic Break conditions. Figure 1 shows examples of the typical prosodic break intonation and the typical continuation intonation. In the Prosodic Break condition (Figure 1, panel A), a pause between NP2 and *and* was present that lasted 321 ms on average (min = 99 ms, max = 514 ms, sd = 75,7 ms). Furthermore, a boundary tone was present on the last syllable of NP2 (i.e., on "...ker" from *kraker* in 6b). This boundary tone consisted of pre-final lengthening of the syllable combined with a pitch rise. The prosodic structure of the constructed target sentences was transcribed by two independent judges using the ToDI system (Gussenhoven, 2004; see ToDI line in Figure 1). The pattern from Figure 1, panel A consists of a pitch accent without a low target (H*) followed by a high boundary tone (%H), a pause, a low boundary tone (%L) and a pitch accent on the third noun (H*L). This pattern occurred in 67% of the sentences with a prosodic break. In addition to this pattern, a pattern without a pitch rise in the boundary tone was observed in 23% of the sentences with a prosodic break (as denoted by the %0 in H* %0 %L H*L). Finally, in 10% of the sentences with a prosodic break a pattern was observed in which there was no low boundary tone following the prosodic break. In this pattern the pitch of the utterance remained high on *en de* (H* %H %H H*L).

In the No Prosodic Break condition (Figure 1, panel B), these features were not present. Instead there were pitch accents on NP2 (*farmer*) and NP3 (i.e., the third noun phrase: *farm hand*). The pattern from Figure 1 Panel B was observed in 68% of the sentences without a prosodic break. In addition to this structure, instances in which the pitch accent on the first of the two NPs was lower than the pitch accent on the second NP occurred in 15% of the sentences without a prosodic break (as denoted by !H*L in !H*L H*L). Finally in 17% of the sentences without a prosodic break the second pitch accent was smaller than the first pitch accent (H*L !H*L). In summary, these transcriptions reveal clear differences between the two prosodic conditions: The prosodic break items all had a pause that was preceded by a boundary tone, the no prosodic break conditions contained a pitch accent on each noun, but did not contain boundary tones or a pause.

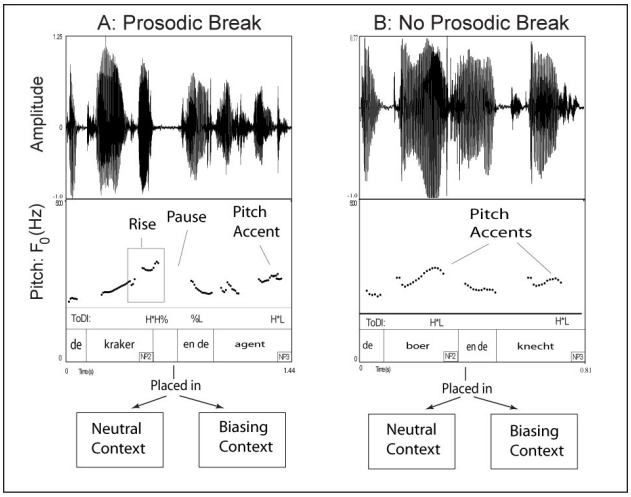


Figure 1: Acoustic properties of a typical critical region of the target sentence. The upper boxes show the amplitude of the speech signal in the Prosodic Break condition (Panel A) and in the No Prosodic Break condition (Panel B). The middle boxes show the pitch-track of the speech signal in both conditions. The lower boxes show the transcription of the speech signal in ToDI (Gussenhoven, 2004) and in words.

2.1.3 Design

The 120 experimental items plus 6 starter items were divided into six blocks. Each block started with one starter item. Two lists were created pseudo-randomly such that the maximum number of items from of a given condition in a row was 3. Each list contained the items in the same order, but in different context conditions. Half of the participants listened to version one and the other half listened to version two. The 14 training items were combined into a training block. Also for this block the list was generated in a pseudo-random fashion.

2.1.4 Apparatus

The EEG was recorded from 25 tin electrodes mounted in an elastic electrode cap. The electrode positions were a subset of the international 10% system, as used in earlier auditory ERP studies (e.g., Kerkhofs et al., 2008). The left mastoid served as reference during the recording, but before the EEG was analyzed, the signal was rereferenced to software-linked mastoids. Electrode impedance was less than 3KΩ. Vertical EOG was recorded bipolary by placing electrodes above and below the right eye. Horizontal EOG was recorded bipolary by placing electrodes beside the left and beside the right eye. The electrode impedance of the EOG electrodes was less than 5 KΩ. EEG and EOG channels were amplified (time constant = 10 s, bandpass = .02 - 100 Hz). All signals were digitized on-line with a sampling frequency of 500 Hz using a 16-bit A/D converter.

2.1.5 Procedure

The items were presented over headphones. A trial started with a warning beep of 100 ms. The auditory presentation of a sentence started 500 ms after offset of the warning beep. The warning beep for the next trial followed 4000 ms after the end of the preceding trial. Because eye movements distort the EEG-signal, the participants were asked to look at a fixation point. They were trained to avoid eye-blinks during the presentation of the items during a training

block of 14 items that preceded the actual experiment. The participants were instructed to listen carefully to each story. They were not given any additional task

2.2 Results

2.2.1 Data analysis

The data was filtered with a low-pass filter of 30 Hz. EEG and EOG records were examined for artifacts and for excessive EOG amplitude during the epoch from 150 ms preceding the offset of NP2 until 1000 ms after offset of NP2. Only trials in which the EOG did not exceed 75 μV, and in which no artifacts (EEG > 100 μV) occurred, were included in the analysis (11.08 % of the trials were excluded).

The window to quantify the CPS was the 400 to 800 ms epoch after NP2 offset. This window was based on visual inspection of the average waveforms, and covers the latency window in which maximal differences between conditions were observed. Separate analyses were conducted for the midline and for the lateral sites. The midline MANOVA had the factors Prosodic Break (break / no break) and Midline Electrode (Fz / Cz / Pz). The MANOVA for the lateral sites had Prosodic Break (absent / present) as factor, using a Hemisphere by Region of Interest (ROI) by Electrode design. The factors Hemisphere and ROI divided the scalp into 4 quadrants: left anterior (AF7, F7, FC3, and F3), right anterior (AF8, F8, FC4, and F4), left posterior (CP5, P7, PO7, and P3), and right posterior (CP6, P8, PO8, and P4).

The results will be presented in the following order. First, it was verified whether a standard CPS was obtained by comparing the prosodic break in the Neutral Context condition with the no prosodic break in the Neutral Context condition. Then it was tested whether the CPS was modulated by discourse context by comparing the identical target sentences with a prosodic break in the Neutral Context and in the Biasing Context conditions.

2.2.2 Standard CPS

Grand average waveforms time-locked to the offset of NP2 for the Neutral Context Prosodic Break condition and the Neutral Context No Prosodic Break condition are presented in Figure 2.

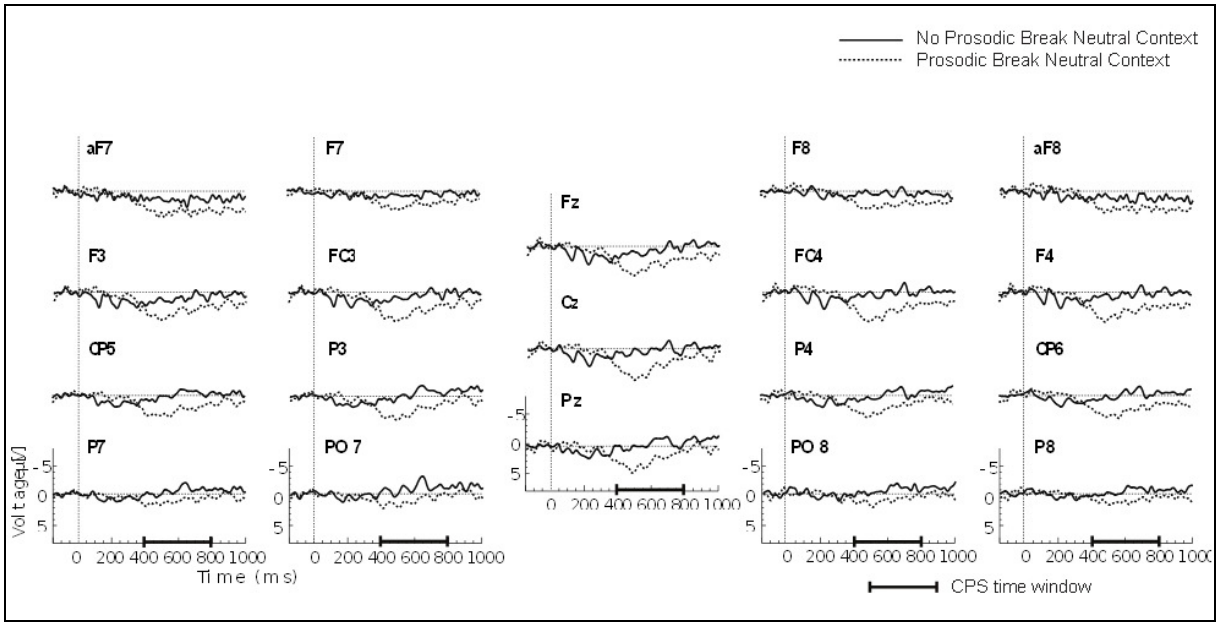


Figure 2: Standard CPS in Experiment 1. Grand average waveforms over participants (n = 30), time-locked to the offset of NP2, for the No Prosodic Break in Neutral Context condition (solid line) and the Prosodic Break in Neutral Context condition (dotted line).

Figure 2 shows that the prosodic break gave rise to a CPS that was broadly distributed across the scalp. In line with this, the midline analysis for the window between 400 and 800 ms yielded a main effect of Prosodic Break ($F[1, 29] = 11.60$; $p < .01$). No interaction of Prosodic Break by Midline Electrode was found ($F < 1$), indicating that the CPS was widely distributed across the midline. Likewise, the lateral analysis yielded a main effect of Prosodic Break ($F[1, 29] = 17.63$; $p < .001$). In addition, a Prosodic Break by Electrode interaction ($F[3, 27] = 4.78$; $p < .01$) and a three-way interaction between Prosodic Break, ROI, and Electrode ($F[3, 27]= 3.13$; $p < .05$) were present. Separate analyses for the two levels of ROI showed effects of Prosodic Break for both the anterior ROI ($F[1, 29] = 19.17$; $p < .01$) and for the posterior ROI ($F[1, 29] = 21.58$; $p < .001$). The three-way interaction indicated that at all individual sites except from two anterior sites (aF7/aF8) a significant CPS effect was obtained. The analyses thus support that the CPS showed a broad scalp distribution with effects being present at frontal, central, and posterior sites.

2.2.3 Modulation of CPS by context

Grand average waveforms time-locked to the offset of NP2 for the identical prosodic break in the Neutral and Biasing Context conditions are presented in Figure 3.

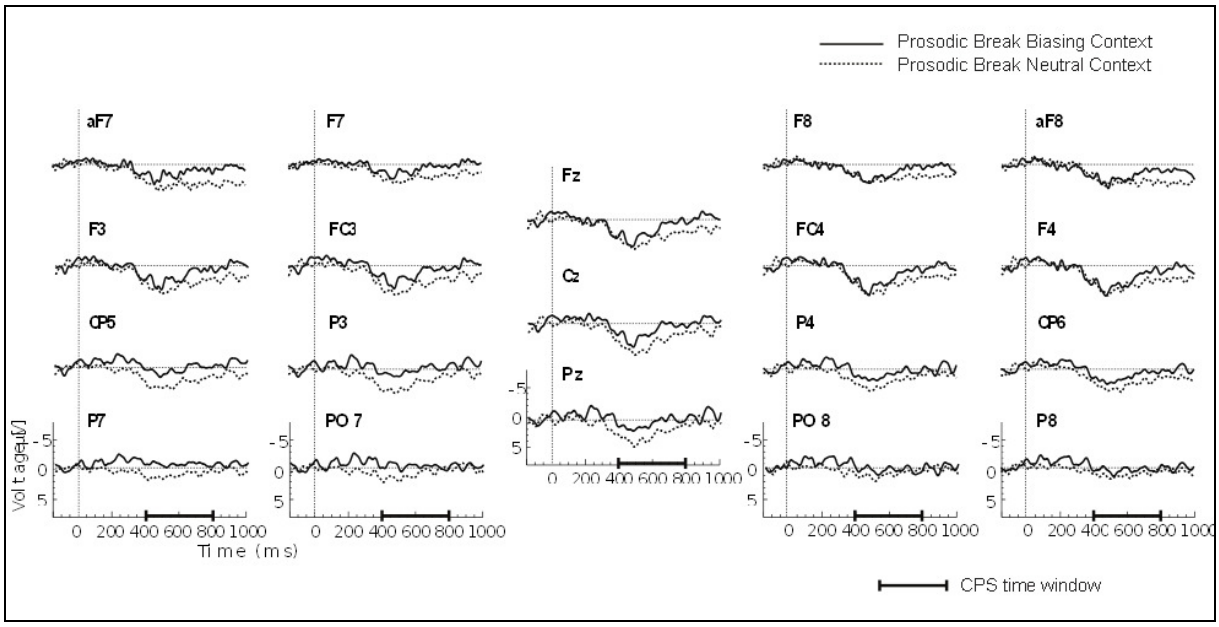


Figure 3: Modulation by Context in Experiment 1. Grand average waveforms over participants (n = 30), time-locked to the offset of NP2, for the Prosodic Break in Neutral Context condition (dotted line) and the Prosodic Break in Biasing Context condition (solid line).

Inspection of Figure 3 suggests that mean CPS amplitudes are more positive for the neutral context compared to the biasing context in the time-window from 400 to 800 ms. This effect is present across the midline, but is most pronounced at centroparietal midline sites (e.g., Cz, Pz). Furthermore, the effect seems to be present over the entire left hemisphere (e.g., FC3, CP5, and P3) and several sites over the right hemisphere (e.g., P4 and CP6). Consistent with this, the midline analysis disclosed an effect of Context ($F[1, 29] = 4.68$; $p < .05$), in the absence of a Context by Midline Electrode interaction ($F < 1$). Also in the lateral analysis a main effect of Context was found ($F[1, 29] = 7.25$; $p < .05$). In addition, this analysis showed a Context by Hemisphere interaction ($F[1, 29] = 5.83$; $p < .05$). Separate analyses for the two Hemispheres showed a clear effect of Context for the left hemisphere ($F[1, 29] = 11.54$; $p < .001$), but not for the right hemisphere ($p > .090$).

2.3 Discussion

The main results of Experiment 1 were as follows. First, the comparison of the prosodic break Neutral Context condition with the no prosodic break Neutral Context condition gave rise to a standard CPS. Second, and most importantly, the CPS to acoustically identical tokens of sentences with a prosodic break was significantly smaller when these sentences were embedded in the Biasing Context condition than when they were embedded in the Neutral Context condition.

The onset latency of the CPS in the present study was somewhat later than those reported in previous studies (e.g., Steinhauer, 2003; Steinhauer et al., 1999). This difference in onsets is likely caused by important differences between the averaging and time-locking procedures that are used in the present study and in previous studies. In the present study we use the default ERP methodology of time-locking each individual trial to a specific critical event and normalize the waveforms in a 150 ms interval directly preceding that event. The critical event in our study is the offset of the second noun (and thus the onset of the pause in the condition with a prosodic break). Previous CPS studies (e.g., Steinhauer, Alter, & Friederici, 1999)

time-locked and normalized the waveforms to the onset of the sentences, computing an average ERP-waveform over the entire sentences. The location of a prosodic break in the auditory signal was then determined by computing the average location of the pause of the prosodic break in the auditory signal. The latency of the CPS is estimated by comparing the point in time at which the prosodic break condition and the no prosodic break condition begin to differ, with the average position of the prosodic break. Clearly, this latter procedure has the disadvantage of "considerable latency variability across trials" (Steinhauer, 2003, p. 151) with respect to the onset of the pause of the prosodic break, a problem that does not occur when time-locking the ERPs to the offset of the word preceding the pause. On the other hand, the procedure used in the present study has the disadvantage that it does not take into account potential contributions of other acoustic aspects of the prosodic break that precede the pause, such as the prefinal lengthening and pitch rise of the boundary tone.

Taken together, it appears that the time-windows in which a CPS is found in the present study and in previous studies cannot be compared directly due to these procedural differences in time-locking and averaging. It should be noted, however, that in the visual domain the onset of the CPS in response to a comma (Steinhauer & Friederici, 2001) shows a similar onset latency as the one observed in the present study. This makes perfect sense as in the visual domain an analogue of our procedure was used: the ERP signals were time-locked to the specific critical event (the appearance of a word with or with no comma attached to it).

In Experiment 1, the prosodic information always was in conflict to the syntactic disambiguation, which occurred several words after the prosodic break (i.e., the second verb in S-coordinations, and the PP in NP-coordinations). One could argue that this aspect of the materials might have led our participants to pay specific attention to the prosodic structure of our materials. Given this consideration, it appears to be necessary to test whether the modulation of the CPS by context generalizes to a situation in which the presence or absence of a prosodic break is always in line with the syntactic disambiguation. Experiment 2 was conducted to clarify this issue.

3 Experiment 2

3.1 Methods

3.1.1 Participants

The participants were 30 undergraduate students with similar characteristics to those from Experiment 1, 4 males and 26 females, aged 19 to 25 (mean age 21.1).

3.1.2 Materials

The same recordings as in Experiment 1 were used to create the materials. The first step was to select one coordination sentence for each item from the recorded pairs. For half of the S-coordination items and half of the NP-coordination items this sentence originated from the biasing context, and for the other half from the neutral context.

In the second step, these target sentences were embedded in neutral and biasing contexts. Half of the neutral context tokens and half of the biasing context tokens were duplicated, resulting in two identical tokens, which were used as the basic frame to construct the final items. For each identical token pair, the target sentence that was selected in the first step was spliced in. This resulted in 120 pairs (60 S-coordination pairs and 60 NP-coordination pairs) of identical stories. Finally, the entire context sentence from the non-duplicated story was cross-spliced over the context sentence in one of the two copies. This resulted in 240 stories,

in which the neutral and the biasing context only differed from each other with respect to the context sentence; the rest of the signal was acoustically identical.

In sum, the auditory stimulus materials consisted of 60 S-coordination sentences with a prosodic break in Neutral and Biasing Context conditions and 60 NP-coordination sentences without a prosodic break in Neutral and Biasing Context conditions.

3.1.3 Design, Apparatus, and Procedure

The design, apparatus, and procedure were identical to those of Experiment 1.

3.2 Results

3.2.1 Data analysis

The data were pre-processed using the same procedure as in Experiment 1 (13.95 % of the trials were excluded because of artifacts). The same set of analyses as in Experiment 1 was carried out.

3.2.2 Standard CPS

Figure 4 shows grand average waveforms time-locked to the offset of NP2 for the Prosodic Break condition and the No Prosodic Break condition, both in neutral context. Inspection of Figure 4 suggests that a small CPS is present at the midline (see for example Fz and Cz) and at some sites of the right hemisphere (see for example FC4 and CP6). However, for the midline sites no effect of Prosodic Break ($p > .25$) or interaction between Prosodic Break and Midline Electrode ($F < 1$) was found. The lateral analysis did not disclose an effect of Prosodic Break ($p > .20$), but did yield an interaction of Prosodic Break by Electrode by ROI ($F[3, 27] = 4.15$; $p < .05$). Separate analyses for the two ROIs revealed an effect of Prosodic Break for the posterior ROI ($F[1, 29] = 5.01$; $p < .05$), but not for the anterior ROI ($F < 1$). Supplementary analyses for the individual electrodes revealed a significant effect of Prosodic Break at three posterior sites over the right hemisphere: CP6, P8, and PO8 (all ps < .05). The CPS in Experiment 2 thus showed a centroparietal scalp distribution that was restricted to the right hemisphere.

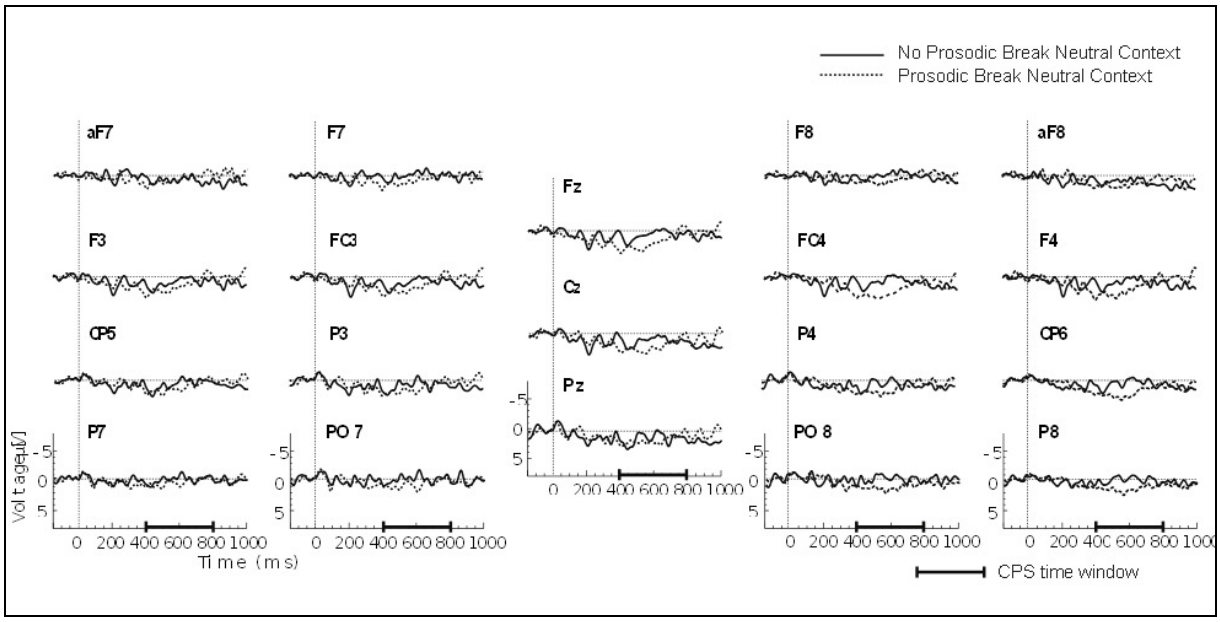


Figure 4: Standard CPS in Experiment 2. Grand average waveforms over participants (n = 30), time-locked to the offset of NP2, for the No Prosodic Break in Neutral Context condition (solid line) and the Prosodic Break in Neutral Context condition (dotted line).

3.2.3 Modulation of CPS by context

Grand average waveforms time-locked to the offset of NP2 for the identical prosodic break in neutral and biasing contexts are presented in Figure 5. Inspection of Figure 5 suggests that overall differences between conditions are small. However, a small context effect seems to be present at the frontal midline site (Fz), a subset of electrodes over the right hemisphere (FC4, CP6, PO8, and P8), and two electrodes of the left hemisphere (P7, and PO7). For the midline sites no effect of Context ($p > .13$), and no interaction with Midline Electrode ($F < 1$) was found. For the lateral sites no main effect of Context ($p > .25$) was found, but the interaction of Context with ROI was significant ($F[1, 29] = 5.10$; $p < .05$). Separate analyses for the two ROIs revealed an effect of Context for the posterior ROI ($F[1, 29] = 4.14$; $p < .05$), but not for the anterior ROI ($F < 1$).

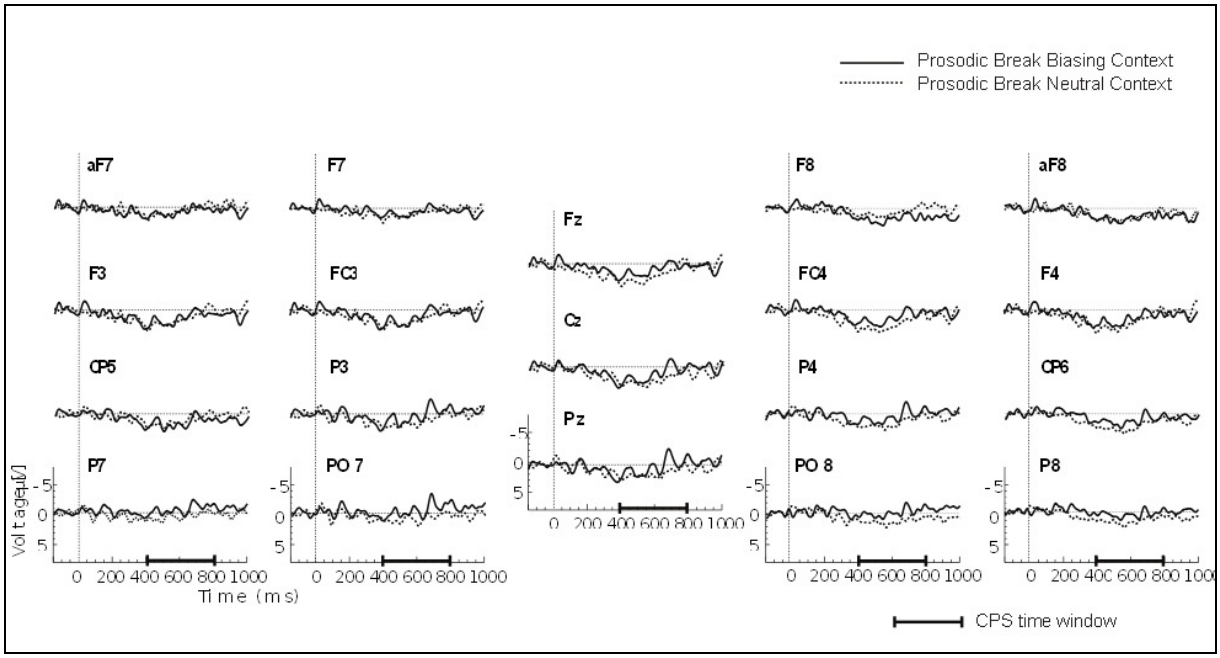


Figure 5: Modulation by Context in Experiment 2. Grand average waveforms over participants (n = 30), time-locked to the offset of NP2, for the Prosodic Break in Neutral Context condition (dotted line) and the Prosodic Break in Biasing Context condition (solid line).

3.3 Discussion

As in Experiment 1, the comparison of the conditions with and without a prosodic break in neutral context yielded a standard CPS. The CPS occurred in the same time-window as in Experiment 1 (i.e., the 400 – 800 ms epoch), but in contrast with Experiment 1, the CPS in Experiment 2 was restricted to the right hemisphere. More importantly, the CPS was smaller when the prosodic break was embedded in a biasing context, i.e., when the prosodic break coincided with the expectation of a syntactic break, than when it was embedded in a neutral context.

In order to test whether the fact that the prosodic information and the syntactic disambiguation were in conflict (Experiment 1) or in-line (Experiment 2) affected the ERPs, additional MANOVAs were performed with Experiment (Experiment 1 / Experiment 2) as an additional between-participant factor. The MANOVAs testing for a standard CPS revealed clear effects of Prosodic Break both for the midline sites ($F[1, 58] = 10.49$; $p < .01$) and for the lateral sites ($F[1, 58] = 15.72$; $p < .01$). No interactions of Prosodic Break with the factor Experiment or other interactions of the factor Experiment with the factors Prosodic Break, Hemisphere, ROI, and/or Electrode were obtained neither for the midline nor for the lateral sites (all ps > .10).

The MANOVAs testing for a modulation of the CPS by discourse context showed main effects of Context both for the midline sites ($F[1, 58] = 6.26$; $p < .05$) and for the lateral sites ($F[1, 58] = 6.87$; $p < .05$). No interactions between the factors Context and Experiment (both ps > .25) or other interactions of these factors with Electrode, Hemisphere, or ROI were present (all ps > .10). This indicates that the modulation of the CPS does not depend on whether the prosodic information is in line with the eventual disambiguation (as in the present experiment), or whether it is in conflict with the eventual disambiguation (as in Experiment 1).

4 General Discussion

The main goal of the present experiments was to shed light on the interaction of prosodic and syntactic information. More specifically, the aim was to test whether prosodic information and syntactic information interact immediately as they become available. In the literature, the effect of prosodic information on the processing of syntactically ambiguous sentences has only been shown several words after the critical prosodic information occurred. To test for the immediate interaction between prosodic and syntactic information, both kinds of information have to be aligned at the same point in the sentence. This alignment is impossible for sentences in isolation, because the presence of a syntactic clause boundary only becomes apparent at the lexical element signaling the syntactic break (e.g., the disambiguating verb in S-coordinations), and this lexical element necessarily follows the syntactic break by one or more words. We provide a solution to this problem by embedding coordination sentences in contexts, which set up the expectation of a syntactic break at the position of a prosodic break, hereby aligning syntactic and prosodic information at the same point in the sentence.

The results from Experiment 1 and Experiment 2 showed a standard CPS. Most importantly, the present study shows a modulation of the CPS in acoustically identical sentences by contextually induced syntactic expectations. This is the case irrespective of whether the eventual lexical disambiguation was in conflict with the prosodic information (Experiment 1) or in line with the prosodic information (Experiment 2).

Up to now we assumed that the positivity following NP2 is a CPS, which is elicited by the prosodic break. However, we have to keep in mind that in the Neutral Context condition a conflict occurs between prosodic information and syntactic information: By default there is an expectancy of syntactic continuity (NP-coordination preference), but the prosodic break suggests a syntactic break. Could it be the case that the positivity reflects the violation of syntactic expectancies by prosodic information? If a prosodic break does induce a syntactic break, reanalysis of the syntactic structure might be required, and a P600 might be elicited. Both the CPS and the P600 are positive shifts that peak around 500 to 600 ms with similar scalp distributions. There is no easy way to discriminate between the two. However, related studies have shown that a CPS is also obtained at positions of a prosodic break that are not associated with any syntactic processing difficulties (e.g., Steinhauer, 2003). Furthermore, the CPS is also obtained in response to prosodic breaks in hummed sentences without any lexical context (e.g., Steinhauer & Friederici, 2001, and Pannekamp et al., 2005). Against the background of these studies it appears highly likely that the positivity observed in the present study also constitutes a CPS. However, even if we were to adopt a P600 interpretation, the observed modulation of the positivity by syntactic expectancy would still provide evidence for an immediate interaction of prosodic and syntactic information in auditory sentence processing.

A related point concerns the fact that the three NPs of the critical target sentences have already been mentioned before the target sentence in the Biasing Context condition, but not in the Neutral Context condition. At the word level it has been shown that repeated words yield a biphasic ERP response – that is, an attenuation of the N400 component followed by an increase of a subsequent late positive component (LPC; see e.g., Nagy & Rugg, 1989). Also at the sentence level, ERP repetition effects have been reported. Besson and Kutas (1993) observed a context-dependent modulation of N400. In particular, they found a decrease in N400 amplitude only when repeated words occurred in the same context but not when repeated words occurred in different contexts. Furthermore, Anderson and Holcomb (2005) showed that N400 repetition effects can occur across a sentence boundary. Note that in the sentential studies repetition affected the N400 measured in the 300 to 600 ms latency window

but - opposite to studies at the word level - did not affect a late positive component. The sensitivity of different ERP components to word repetition at the word and the sentence level (N400, and LPC) raises the question whether the modulation of the CPS by discourse context could be due to the repetition of the noun following the onset of the prosodic break (noun 3) in the Biasing Context condition. A closer look at the timing of the events in our study shows, however, that the context modulation of the CPS in our study cannot be due to repetition vs. no repetition of the word following the prosodic break. The average length of the pause following NP2 was 321 ms. The average length of "en de" (*and the)* in the prosodic break condition was 174 ms (sd = 37 ms). Thus, the onset of the third noun occurs 495 ms after the onset of the pause. But the modulation of the CPS already started at 400 ms following the onset of the pause, i.e., on average 95 ms before the onset of the third noun. This makes it impossible that the modulation is caused by the repetition of this third noun.

Up to now, we have shown that the presence of a prosodic break is matched immediately against the expectation of a syntactic break by comparing identical tokens of sentences with a prosodic break in two context conditions (neutral vs. biasing context). But is the presence of a prosodic break alone sufficient to disambiguate the sentence towards an S-coordination, or is complete early disambiguation only possible if the prosodic break coincides with the syntactic expectation of a break? To answer this question, we contrasted the waveforms at the disambiguating verb in S-coordination sentences with a prosodic break in neutral contexts and in biasing contexts. If the prosodic break alone is sufficient for early disambiguation, the waveforms at the disambiguating verb should not show a difference between the neutral and the biasing contexts. If a prosodic break only leads to an early disambiguation when also a syntactic break is expected at this point in the sentence, the sentences in biasing context should be disambiguated at the prosodic break, whereas the sentences in neutral context should remain ambiguous up to the disambiguating verb. This should lead to processing difficulty at the disambiguating verb in the Neutral Context condition relative to the Biasing Context condition. The results at the disambiguating verb showed no differences between the neutral and biasing contexts, indicating that the prosodic break alone was sufficient to disambiguate the sentences as S-coordinations (see Chapter 4 for complete data sets, analyses, and detailed discussion of the results). This is in line with the findings of Steinhauer et al. who have shown that a prosodic break can induce garden paths in isolated sentences (Steinhauer et al., 1999).

The main findings of the present study can be summarized as follows: First, we replicated a CPS in response to the occurrence of a prosodic break as compared to sentences without a prosodic break. Second, and crucially, using a discourse context manipulation, we have demonstrated that the CPS elicited by an acoustically identical prosodic break is modulated as a function of a contextually induced syntactic expectation. When the prosodic break coincided with a syntactic break, the CPS was significantly smaller than when the prosodic break did not coincide with a syntactic break. This result shows that syntactic information and prosodic information interact, and crucially, that they interact immediately at the point at which the prosodic information becomes available.

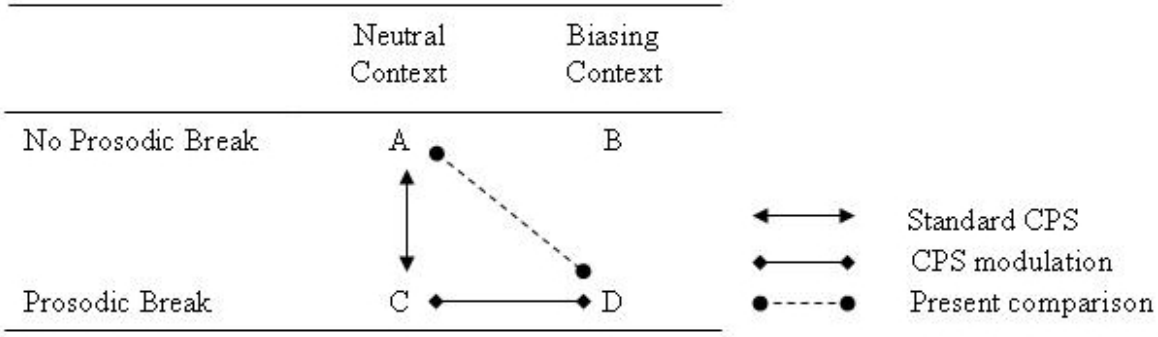
The picture that emerges from the available literature is that prosodic information is able to guide the parser, and helps to predict upcoming materials. To date, little information on the time-course of this process is available. Based on the present data we cannot tell whether prosodic information is primary and driving the syntactic analysis, or whether syntactic information is primary and prosodic information is used to confirm the syntactic structure. What the present results do reveal, however, is that both sources of information are matched immediately as they become available. That is, there is no delay in the usage of prosodic information. This immediate interaction of prosody and syntax only becomes evident when

studying the processing of sentences in a discourse context instead of focusing on the processing of isolated sentences.

5 Supplementary analyses I: Prosodic break in the biasing context condition

Until now Chapter 3 explored whether prosodic and syntactic information interact immediately when they become available. To this aim we constructed a design in which syntactic expectation based on context (Neutral Context vs. Biasing Context) was completely crossed with prosodic information (Prosodic Break vs. No Prosodic Break; see Table 3). Using this design, it was shown that the prosodic break elicited a CPS. This was done by comparing the Prosodic Break condition in Neutral Context with the No Prosodic Break condition in Neutral Context (A vs. C in Table 3). In a second step, the question was addressed whether syntactic information and prosodic information interact immediately by comparing the Prosodic Break condition in the Neutral Context condition with the Prosodic Break condition in the Biasing Context condition (C vs. D in Table 3). The CPS to the identical prosodic break was modulated by the contextually induced syntactic expectations. Waveforms to the prosodic break in the Neutral Context condition were more positive-going than to the identical prosodic break in the Biasing Context condition.

Table 3. Contrasted conditions in Supplementary analyses I



But this does not provide an answer to the question whether in the Biasing Context condition a CPS is still elicited, or whether the CPS is altogether absent. Put differently, does the modulation of the CPS by context imply a smaller CPS, or does it imply the complete absence of a CPS in the Biasing Context condition. To answer this question, the present supplementary analyses contrast the Prosodic Break in the Biasing Context condition with the same neutral baseline as used earlier for the standard CPS, the No Prosodic Break Neutral Context condition (A vs. D in Table 3)[3]. If the CPS in the Biasing Context condition is merely mitigated, a CPS should be elicited. On the other hand, if the contextually induced syntactic expectations are so strong that the CPS is absent altogether, no difference should be found between the No Prosodic Break Neutral Context condition and the Prosodic Break Biasing Context condition.

[3] The contrast No Prosodic Break Biasing Context vs Prosodic Break Biasing Context (B vs. D) is not provided. The problem with this contrast is that neither condition provides a neutral baseline. In the No Prosodic Break Biasing Context condition, the absence of a prosodic break and the biasing context work against each other. In the Prosodic Break Biasing Context condition the prosodic break elicits a CPS, but the CPS is modulated by the biasing context. As a result, effects that would be obtained would be difficult to interpret.

Results

Data analysis

Experiments 1 and 2 were analyzed separately, followed by a between-experiment analysis with Experiment as a between-participant factor (as in the Discussion section of Experiment 2 in the main part of Chapter 3). The design of the analyses for the midline sites and for the lateral sites were identical to those reported earlier. Again, the factors Context, Hemisphere, Region of Interest, and Electrode were crossed. The analyses in the present section test for the presence of a CPS for the prosodic break in the Biasing Context condition, relative to the condition without a prosodic break in the Neutral Context condition. Again, the 400 to 800 ms time-window was used to quantify the effects. To increase the sensitivity to detect possible differences between conditions we also performed the same set of analyses for the four consecutive 100 ms time-windows within the broad window from 400 to 800 ms.

Experiment 1

Grand average waveforms for the No Prosodic Break Neutral Context condition and the Prosodic Break Biasing Context condition time-locked to the offset of NP2 are presented in Figure 6. Visual inspection suggests the presence of a CPS at right-lateral electrodes (e.g., F4, FC4). The midline analysis for the CPS-window did not disclose an effect of Prosodic Break ($p > .90$), nor an interaction of this factor with Midline Electrode ($F < 1$).The lateral analysis yielded a trend for an effect of Prosodic Break ($F[1, 29] = 3.80$; $p = .061$). In addition, a four-way interaction between Prosodic Break, Hemisphere, ROI, and Electrode was found ($F[3, 27] = 3.12$; $p < .05$). Follow-up analyses for the anterior and posterior ROIs did not disclose a main effect of Prosodic Break for any of the four ROIs (all ps > .15). However, follow-up t-tests for the 4-way interaction for individual electrodes confirmed the presence of a CPS for a subset of right hemisphere electrodes (F8, FC4, and F4; all ps < .05).

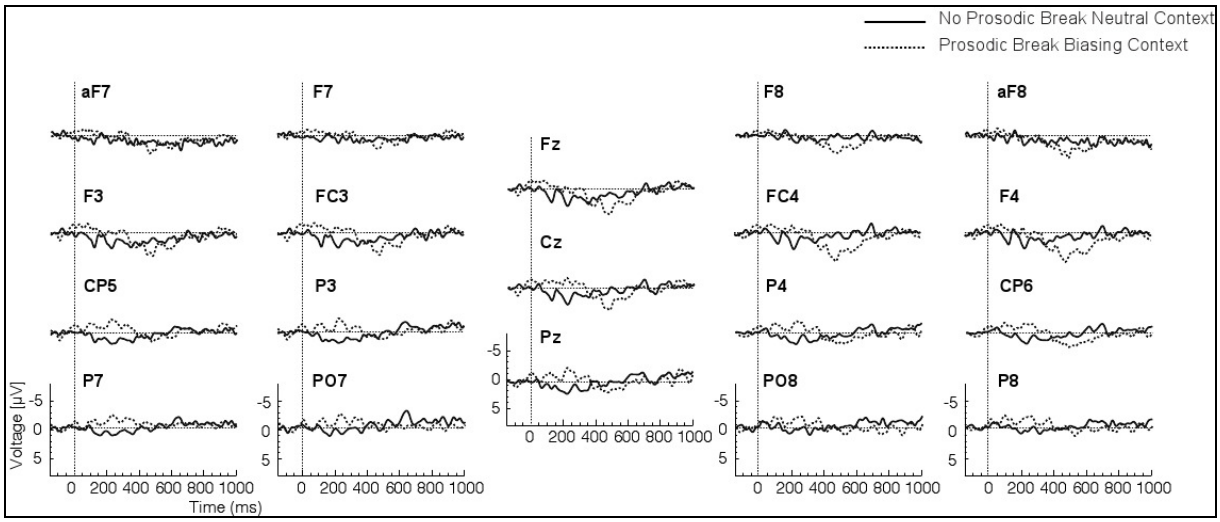


Figure 6: CPS in Biasing Context condition in Experiment 1. Grand average waveforms over participants (n = 30), time-locked to the offset of NP2, for the No Prosodic Break in Neutral Context condition (solid line) and the Prosodic Break in Biasing Context condition (dotted line).

The time-course analyses provided a more detailed picture. The analyses for the midline electrodes revealed a main effect for Prosodic Break from 400 to 500 ms ($F[1, 29] = 7.60$; $p < .01$); no main effects for Prosodic Break were found in the later epochs (from 500 to 800 ms; all ps > .090). The time-course analyses for the lateral electrodes yielded main effects

for Prosodic Break from 400 to 600 ms (both Fs > 5.22; both ps < .05), but not from 600 to 800 ms (both ps > .12). The interaction between Prosodic Break and Electrode was significant from 400 to 500 ms ($F[3, 27] = 4.09$; $p < .05$), but not from 500 to 800 ms ($p > .10$). The interaction between Prosodic Break and Hemisphere was significant from 400 to 600 ms (both Fs > 4.64; both ps < .05). Follow-up analyses for the left and the right hemisphere in these two time-windows (from 400 to 600 ms) showed an effect of Prosodic Break for the right hemisphere (both Fs > 8.41; both ps < .01), but not for the left hemisphere (both ps > .25). Follow-up t-tests for individual electrodes indicated that a significant effect was present at the following sites: AF8, F8, FC4, and CP6 (all ps < .05). The results of the time-course analyses thus further support that a CPS was elicited by the prosodic break in the Biasing Context condition.

Experiment 2

Grand average waveforms time-locked to the offset of NP2 for the No Prosodic Break Neutral Context condition and the Prosodic Break Biasing Context condition are presented in Figure 7. Visual inspection suggests that no CPS was elicited by the prosodic break. In line with this, for the midline analysis no effect for Prosodic break was obtained ($F < 1$), and no interactions of this factor with Midline Electrode ($p > .15$). Likewise, for the lateral analysis no effect for Prosodic Break ($F < 1$), and no interactions of Prosodic Break with Hemisphere, ROI or Electrode were found (all ps > .16).

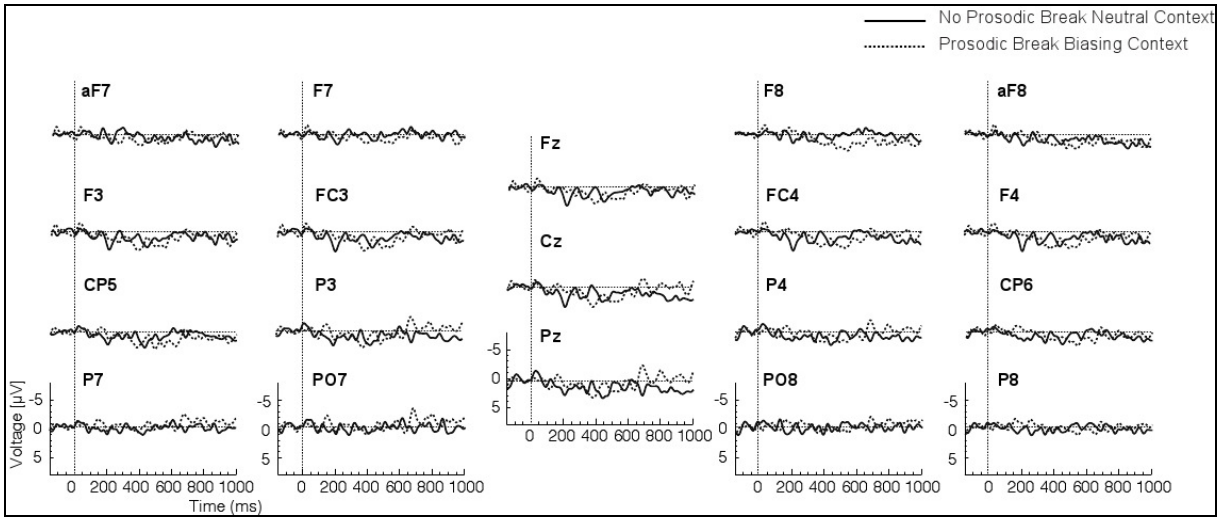


Figure 7: CPS in Biasing Context condition in Experiment 2. Grand average waveforms over participants (n = 30), time-locked to the offset of NP2, for the No Prosodic Break in Neutral Context condition (solid line) and the Prosodic Break in Biasing Context condition (dotted line).

The time-course analyses for the midline electrodes did not show effects of Prosodic Break (all ps > .20), or any interactions (all ps > .080). The time-course analyses for the lateral electrodes also did not show effects of Prosodic Break (all Fs < 1). For the 500 to 600 ms epoch a trend for an effect of Prosodic Break was found ($F[1, 29] = 3.95$; $p = .056$). No interactions between Prosodic Break, Electrode, ROI, or Hemisphere were found (all ps > .10). The results of both kinds of analysis indicate that no reliable CPS was elicited by the prosodic break in the Biasing Context condition.

Between-experiment comparison

The between-experiment MANOVAs with the factor Experiment (Experiment 1 / Experiment 2) as between participant factor for the broad window (400 to 800 ms) revealed no effect of Prosodic Break, neither in the midline analysis nor in the lateral analysis (both ps > .09). There was an interaction between Prosodic Break and ROI in the lateral analysis ($F[1, 58] = 4.07$; $p < .05$), and a three-way interaction between Electrode, Hemisphere, and Context ($F[3, 56] = 3.72$; $p < .05$). Follow-up analyses for each ROI separately revealed a marginal effect for Prosodic Break for the anterior electrodes ($F[1, 58] = 3.61$; $p = .062$), but no effect for the posterior electrodes ($F < 1$). Follow-up analyses for each level of electrode indicated that a significant effect of prosodic break was present at the sites F8, FC4, and CP6 (all ps < .05). The interaction between Experiment and Prosodic Break was not significant, neither for the midline sites nor for the lateral sites (both ps > .20). Additionally, no other interactions with the factor Experiment were obtained (all ps > .10).

Discussion

The results of Experiment 1 showed that the prosodic break in the Biasing Context condition elicited a small CPS, relative to the No Prosodic Break in the Neutral Context condition. The results for Experiment 2 showed no evidence for a CPS at all. The results from the between-experiment analyses confirm that there was no overall reliable evidence for a CPS. These results support the claim that the biasing context can be such a strong cue that no CPS is elicited following a prosodic break. The absence of a CPS in Experiment 2 furthermore implies that the presence of a prosodic break alone is not sufficient to elicit a CPS. This suggests that a CPS does not reflect the mere processing of a prosodic break as an acoustic event. So, what does the CPS reflect?

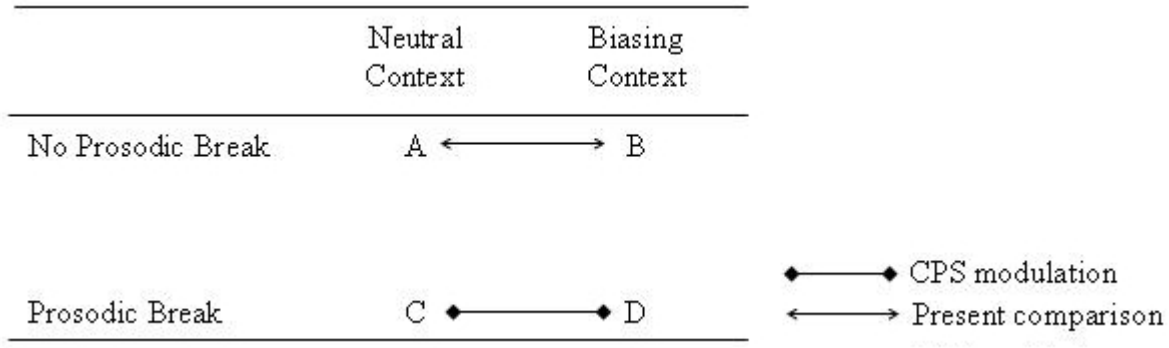
In Chapter 2, we already argued that the CPS has an attentional component. We proposed that the CPS can be reduced in size as a function of the amount of attention allocated to the relevant cue (be it a comma or a prosodic break) or the saliency of the cue eliciting the CPS (see the general discussion of Chapter 2 for the relevant evidence). It could be the case that the prosodic break in the Biasing Context condition is less salient than in the Neutral Context condition, because in the Biasing Context condition it coincides with the expectancy of a syntactic break. Because of this reduced saliency, less attention is given to the prosodic break, and consequently the CPS is reduced in amplitude, or even altogether absent. This notion is compatible with recent findings by Knösche et al. (2005) who linked a CPS-like effect to attentional processing.

If we were to disregard the results from the between-experiment analyses and accept that Experiment 1 did show a CPS, whereas Experiment 2 did not, could the attentional component also explain the different patterns in Experiment 1 and Experiment 2? In the Biasing Context condition of both experiments, the presence of a prosodic break is also motivated by the context. However, it is conceivable that the participants were more focused on the prosodic structure in Experiment 1, where prosodic information and eventual syntactic disambiguation always were in conflict, than in Experiment 2, where prosodic information and eventual syntactic disambiguation always were in line. Therefore, a prosodic break might be more salient in the Biasing Context condition of Experiment 1, than in the Biasing Context condition of Experiment 2.

6 Supplementary analyses II: Can the absence of a prosodic break signal syntactic coherence?

In the main part of Chapter 3, the direct interaction between syntactic information and prosodic information was demonstrated by comparing identical prosodic breaks in two context conditions (C vs. D in Table 4; Table 4 is adapted from Supplementary Analyses I). The present section addresses the question whether the absence of a prosodic break can also be a prosodic cue that can be matched against syntactic expectations. To explore this question, the ERPs time-locked to the offset of the second NP in sentences without a prosodic break (i.e., to the onset of "and") in the Neutral Context condition and the Biasing context condition are contrasted (A vs. B in Table 4).

Table 4. Contrasted conditions in Supplementary analyses II



If the absence of a prosodic break is a prosodic cue that is matched against the contextually induced syntactic expectations, different brain responses should be observable in the Neutral Context condition relative to the Biasing Context condition. In the Biasing Context condition, the absence of a prosodic break does not match the expectation of a syntactic break. By contrast, in the Neutral Context condition, the default syntactic preference for an NP-coordination holds, and thus the absence of a prosodic break matches the expectation of syntactic continuity. Since the absence of a prosodic break cannot be linked to a specific ERP component, it is impossible to make predictions with regard to the possible ERP effects. Therefore, these analyses have an exploratory character.

Results

Data analysis

The design of the analyses for the midline sites and for the lateral sites were identical to the analyses reported earlier in this chapter. Again, the factors Context, Hemisphere, Region of Interest, and Electrode were crossed.

Experiment 1

Grand average waveforms for the No Prosodic Break Neutral Context condition and the No Prosodic Break Biasing Context condition are presented in Figure 8.

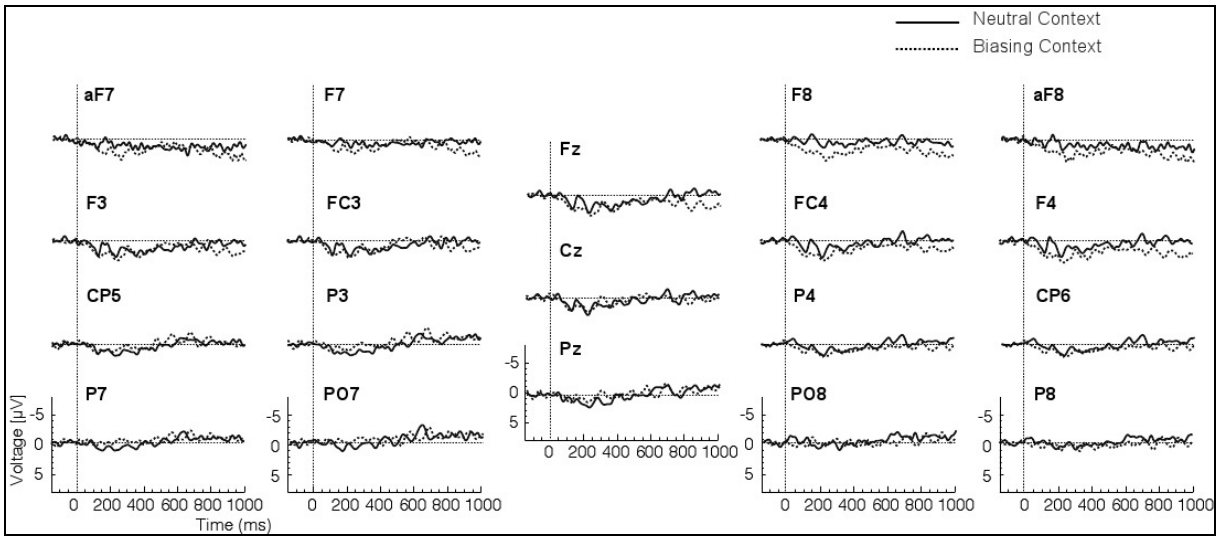


Figure 8: No Prosodic Break in Neutral and Biasing contexts in Experiment 1. Grand average waveforms over participants (n = 30), time-locked to the offset of NP2, for the No Prosodic Break in Neutral Context condition (solid line) and the No Prosodic Break in Biasing Context condition (dotted line).

Inspection of the waveforms suggests a positive-going deflection for the Biasing Context condition relative to the Neutral Context condition from about 100 ms to 300 ms (see e.g., AF8, F8, and F4). This window was used in the analyses. The analysis for the midline electrodes did not show an effect of Context ($F < 1$). An interaction between Context and Midline Electrode was found ($F[2, 28] = 4.81$; $p < .05$). Follow-up analyses for the single sites, however, did not reveal reliable differences for any of the electrodes (all ps > .12). The analysis for the lateral electrodes did not yield a main effect of Context ($p > .25$). A two-way interaction between Context and Region of Interest ($F[1, 29] = 18.32$; $p < .001$), a three-way interaction between Context, Hemisphere, and Electrode ($F[3, 27] = 5.03$; $p < .01$), and a four-way interaction between Context, Region of Interest, Hemisphere and Electrode ($F[3, 27] = 3.23$; $p < .05$) were present. Separate analyses for each ROI yielded main effects of Context for the two anterior ROIs (both Fs > 4.45; both ps < .05). Follow-up t-tests for individual electrodes indicated that a significant effect was present at the sites AF7, AF8, and F4 (all ps < .05). For the posterior ROIs no effects were obtained (both ps > .10).

Experiment 2

Grand average waveforms for the No Prosodic Break Neutral Context condition versus the No Prosodic Break Biasing Context condition are presented in Figure 9. Visual inspection of the waveforms suggests a negative-going deflection for the Biasing Context condition relative to the Neutral Context condition from 400 to 500 ms peaking at 450 ms (e.g., see Pz). Because we did not want to rely on such a small window, we also performed a time-course analysis on 100 ms consecutive windows. The time-course analyses did not reveal main effects of Context for any two consecutive windows, or interactions with Context.

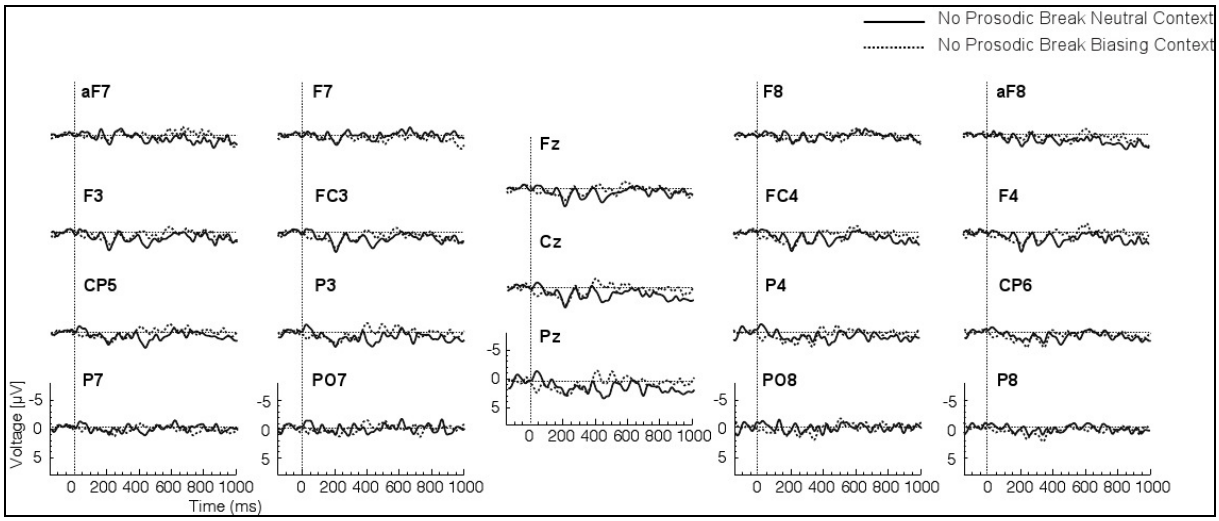


Figure 9: No Prosodic Break in Neutral and Biasing contexts in Experiment 2. Grand average waveforms over participants (n = 30), time-locked to the offset of NP2, for the No Prosodic Break in Neutral Context condition (solid line) and the No Prosodic Break in Biasing Context condition (dotted line).

A between-experiment analysis including the factor Experiment was not performed. The effect from Experiment 1 and the non-significant deflection from Experiment 2 differed in time-course and polarity. Therefore, potential effects in a between-experiment analysis would not be informative.

Discussion

This section explored whether the absence of a prosodic break could potentially be a prosodic cue that can be matched against syntactic information. We obtained different results in Experiment 1 and in Experiment 2. In Experiment 1, we found an early positivity for the Biasing Context condition from 100 to 300 ms. By contrast, in Experiment 2 no effects were obtained.

Earlier in Chapter 3 we have shown that a prosodic break is a cue that is matched against contextually induced syntactic expectations as soon as this cue becomes available. The present section provides some, admittedly weak, evidence that also the absence of a prosodic break can be a cue that is matched against contextually induced expectations. This can only be the case if the brain notices and uses the absence of a prosodic break. However, the results did not show the same pattern in both experiments. A difference in the design of Experiments 1 and 2 might have caused these different patterns. In Experiment 1, the absence of a prosodic break was never paired with an eventual NP-coordination disambiguation of the sentence, while in Experiment 2 the absence of a prosodic break always correctly signaled an NP-coordination. As a result, it could be the case that the absence of a prosodic break was more salient in Experiment 1 than in Experiment 2. This difference may have led participants to use the absence of a prosodic break differently in both experiments.

If the absence of a prosodic break is a cue that can be used to guide parsing, what would it signal? The most likely candidate is that it would signal syntactic continuity. In their review paper, Cutler et al. (1997, page 166 and 170) suggest that a full test of whether prosody can determine the syntactic commitment at an ambiguous point in a sentence, one has to show that prosody can induce both syntactic break and syntactic continuity. The present analyses provide some weak indication that prosody might indeed be able to not only indicate a syntactic break, but also syntactic continuity.

Until now, in Chapter 3, we have not been looking at the lexically disambiguating region. However, in Chapter 2 we have already seen that a prosodic break can induce an S-coordination reading which shows up on the lexically disambiguating verb. In Chapter 4 we will also move several words downstream from the position of the prosodic information to the position of the syntactically disambiguating region of the coordination sentences.

Chapter 4. The effect of contextual expectations and prosodic information on the syntactic disambiguation of the coordination ambiguity.

1 Introduction

Chapter 3 explored the immediate interaction between prosodic information and syntactic information. This interaction was demonstrated in sentences with a local ambiguity at the point at which the relevant prosodic information, a prosodic break, occurred. However, whether the prosodic break actually is used to disambiguate the syntactically ambiguous sentences can only be tested several words downstream from the prosodic break where the sentences are disambiguated lexically. The present chapter reports the data from the two experiments described in Chapter 3 at this syntactically disambiguating point[1].

The design that was used for the two experiments is presented in Table 1 (adapted from Table 2 in Chapter 3). As can be seen in Table 1, in Experiment 1 the prosodic information always was in contrast to the syntactic disambiguation, whereas in Experiment 2 the prosodic information always was in line with the syntactic disambiguation. A split into two separate experiments was necessary because a complete crossing of the factors Context, Prosodic Information, and Syntactic Disambiguation within a single experiment would have resulted in an experiment that would have been too long. A consequence of this design is that we are unable to test for the effect of prosody at the point of syntactic disambiguation in the same way as in Chapter 2. In Chapter 2, the identical syntactic information (i.e., the disambiguating verb of the S-coordination sentences) was contrasted in two Prosody conditions (presence of a prosodic break and absence of a prosodic break).

Table 1. Contrasts of present chapter

Experiment	Prosodic break	Lexically disambiguated as	Context contrast
Experiment 1	No	S-coordination	1: Neutral Context versus Biasing Context
	Yes	NP-coordination	2: Neutral Context versus Biasing Context
Experiment 2	Yes	S-coordination	3: Neutral Context versus Biasing Context
	No	NP-coordination	4: Neutral Context versus Biasing Context

In the present chapter we examine the combined effects of context and prosody at the point of syntactic disambiguation. For the S-coordination sentences the point of syntactic

[1] A brief summary of the results of the present chapter has already been given in the General Discussion of the main part of Chapter 3. As the main part was published as an article in *Journal of Cognitive Neuroscience*, space limits imposed by the journal made it impossible to discuss the present data in detail there.

disambiguation is the theoretical uniqueness point of the disambiguating verb. For the NP-coordinations the point of syntactic disambiguation is defined as the onset of the prepositional phrase (PP) following the coordination[2]. The combined effects of Prosody and Context yield four contrasts (see Table 1).

In the first contrast, we compare the syntactically disambiguating verb of the S-coordinations without a prosodic break in the Neutral Context condition with the identical verb embedded in the Biasing Context condition. Predictions for this comparison are not straightforward. In the Neutral Context condition, an NP-coordination is expected based on the default NP-coordination preference. Additionally, no S-coordination is expected based on the prosodic information. By contrast, for the S-coordination sentences without a prosodic break in the Biasing Context condition, an S-coordination is expected based on the context, but an S-coordination is not expected on the basis of the prosodic information. Thus, the Neutral Context condition contained two signs pointing to the other disambiguation than the (eventual) syntactic disambiguation (hereafter contra-signs). The Biasing Context condition contained one contra-sign. As a result, the comparison of the disambiguating verb in the Neutral Context condition and in the Biasing Context condition concerns the comparison of two contra-signs (Neutral Context condition) with one contra-sign (Biasing Context condition).

The second contrast concerns the PP of the NP-coordinations that are preceded by a prosodic break in the Neutral versus the Biasing Context condition. Again, predictions are not straightforward. The Neutral Context condition does not set up any syntactic expectations. As a result the basic NP-coordination preference will hold. However, the prosodic break should induce the expectation for an S-coordination. By contrast, in the Biasing Context condition both the context and the prosodic information signal an S-coordination. By contrasting these two conditions a contrast between one contra-sign (in the Neutral Context condition) and two contra-signs (in the Biasing Context condition) is made.

The third contrast concerns the syntactically disambiguating verb of the S-coordinations with a prosodic break in the Neutral versus the Biasing Context condition. We know from earlier studies that the Biasing Context condition disambiguates coordination sentences as S-coordination sentences (Hoeks, Vonk, & Schriefers, 2002). Furthermore, in Chapter 2, it was established that a prosodic break disambiguates a coordination sentence in isolation as an S-coordination sentence. Thus, the presence of a prosodic break in both conditions (neutral context and biasing context) should suffice to disambiguate the sentences as S-coordination sentences, and, as a result, we should not observe differences between the S-coordination sentences with a prosodic break in Neutral Context and in Biasing Context.

The final contrast concerns the PP of the NP-coordinations that are not preceded by a prosodic break in the Neutral versus the Biasing Context condition. In the Neutral Context condition, an NP-coordination is expected based on the default NP-coordination preference. In the Biasing Context condition, however, the context sets up an S-coordination expectation. If the absence of a prosodic break is a prosodic cue that signals an NP-coordination (i.e., syntactic continuity, see Supplementary Analyses II from Chapter 3) it is possible that it overrules the S-coordination bias that is set up in the biasing context. If this is the case, no difference between the two conditions will be obtained. On the other hand, if the absence of a prosodic break does not provide a reliable cue for an NP-coordination, or if the S-coordination bias of the Biasing Context condition is strong enough to override the potential effects of the absence of a prosodic break, a difference between the waveforms might be

[2] Although syntactically the NP-coordinations do not disambiguate until the end of the sentence, our materials were constructed in such a way that pragmatically they disambiguated at the PP following the coordination (see materials sections of Chapter 2 and Chapter 3).

obtained. Below we present the ERP results for these four contrasts (contrasts 1 and 2 in Experiment 1, contrasts 3 and 4 in Experiment 2).

2 Methods

Participants, materials, design, and experimental procedure are reported in Chapter 3. Instead of time-locking to the prosodic break, this chapter reports the data time-locked to the point of syntactic disambiguation of the coordination sentences, i.e., the theoretical uniqueness point of the syntactically disambiguating verb[3], or the onset of the PP.

3 Results

3.1 Data analysis

The design of the analyses for the midline sites and for the lateral sites were identical to those in Chapter 3. Again, the factors Context, Hemisphere, Region of Interest, and Electrode were crossed. No a priori windows were defined. Time-course analyses on 100 ms consecutive time-windows were performed. Effects are only reported if at least two consecutive time-windows show significant effects.

3.2 Experiment 1: Prosodic structure in conflict with eventual disambiguation

3.2.1 S-coordinations: Verb in neutral and biasing contexts

Grand average waveforms time-locked to the uniqueness point of the disambiguating verb for the S-coordination sentences without a prosodic break in the Neutral Context and in the Biasing Context condition in Experiment 1 are presented in Figure 1. Inspection of the waveforms suggests that the waveforms for the Biasing Context condition are more positive going from 0 to around 600 ms (see for example electrodes aF7, F7, and FC3).

[3] The use of the theoretical uniqueness point is a relatively accurate way to deal with the variance of the onset of the critical information in the auditory modality. See Appendix I for further details.

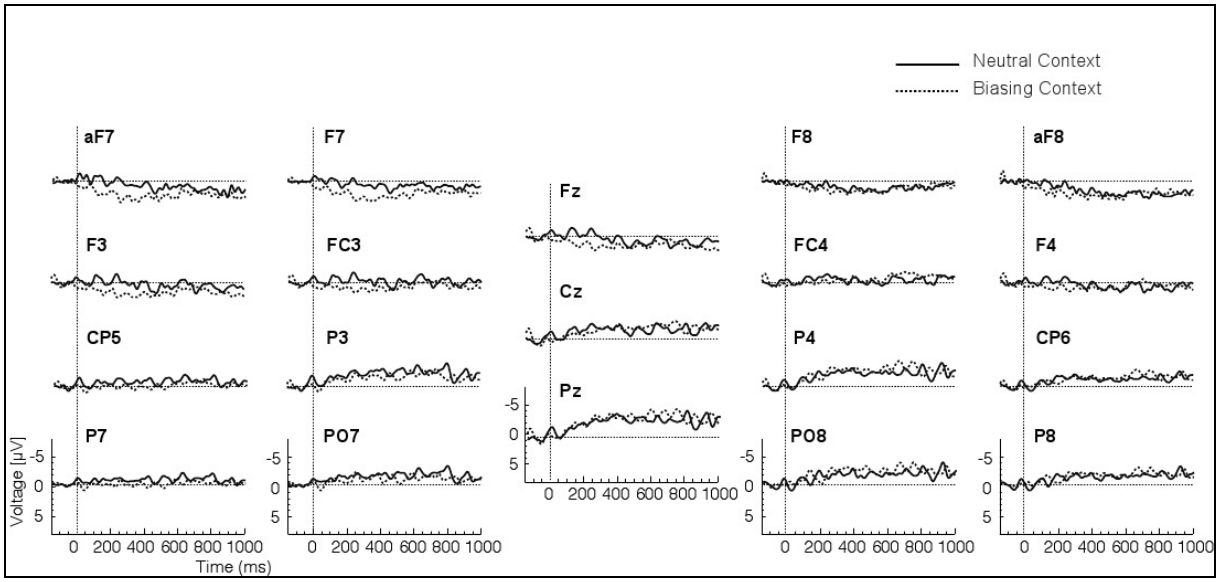


Figure 1: S-coordination sentences without a prosodic break in Experiment 1. Grand average waveforms over participants (n = 30), time-locked to the uniqueness point of the disambiguating verb for the Neutral Context condition (solid line) and the Biasing Context condition (dotted line).

The analyses for the midline sites did not show an effect of Context in any of the time-windows (all ps > .15). Likewise, the interaction between Context and Midline Electrode was not significant in any of the time-windows (all ps > .75).

The analyses for the lateral sites showed effects of Context from 100 to 300 ms (both Fs > 5.87; both ps < .05). No effects of Context were found from 300 to 1000 ms (all ps > .10). In addition, the interaction between Context and Hemisphere was significant from 100 to 700 ms (all Fs > 6.11; all ps < .05), but not for the later windows from 800 to 1000 ms (p > .30). Separate analyses for the left and the right hemisphere showed main effects of Context from 100 to 400 ms for the left hemisphere (all Fs > 8.92; all ps < .01), but not for the right hemisphere (all ps > .15). From 400 to 600 ms the left hemisphere electrodes disclosed a trend towards an effect of Context (both Fs > 3.45; both ps < .074); again, no effects were found for the right hemisphere electrodes (both Fs < 1).

3.2.2 NP-coordinations: PP in neutral and biasing contexts

Grand average waveforms time-locked to the onset of the prepositional phrase for the NP-coordination sentences in the Neutral Context and in the Biasing Context condition in Experiment 1 are presented in Figure 2. Inspection of the waveforms suggests that the waveforms for the Biasing Context condition are more positive going at some anterior electrodes (see, for example, electrodes aF7 and F7), but more negative going at other electrodes (see, for example, the midline electrodes Cz and Pz).

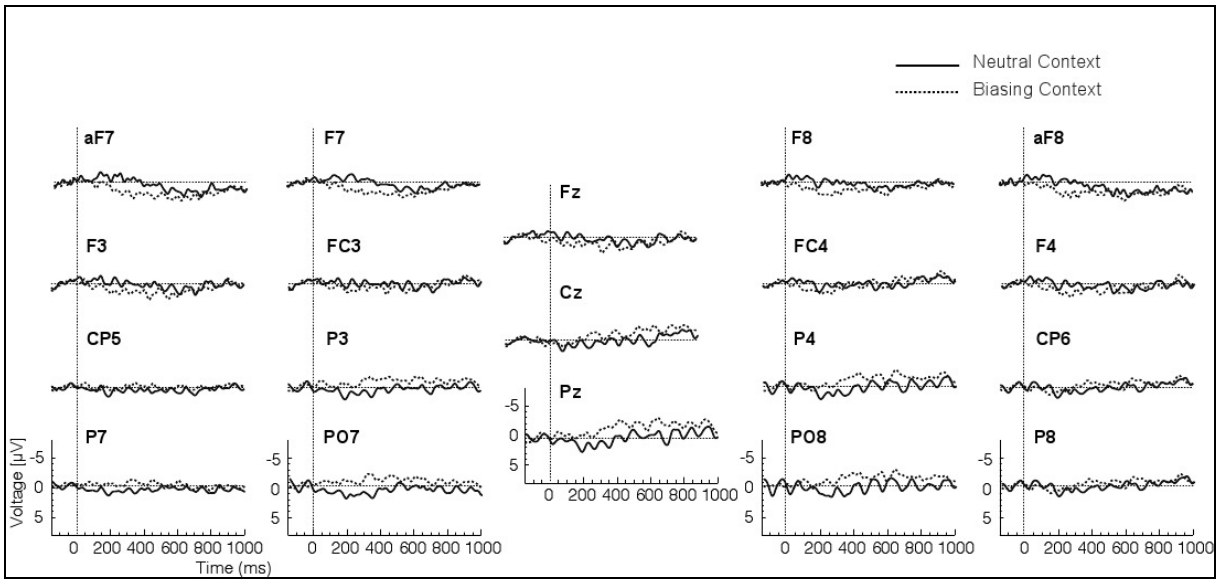


Figure 2: NP-coordination sentences with a prosodic break in Experiment 1. Grand average waveforms over participants (n = 30), time-locked to the onset of the PP for the Neutral Context condition (solid line) and the Biasing Context condition (dotted line).

The analyses for the midline sites did not show a main effect of Context in any of the windows (all ps > .10). The interaction between Context and Midline Electrode was significant from 0 to 800 ms (all Fs > 3.40; all ps < .05). Follow-up analyses for single sites showed effects for Context at Pz (all ps < .05), but not at Fz and Cz (all ps > .080). No effects were found from 800 to 1000 ms (both ps > .080).

The analyses for the lateral sites did not show an effect of Context (all ps > .20) in any of the windows. The interaction between Context and ROI was significant from 0 to 500 ms (all Fs > 3.30; all ps < .05). Follow-up analyses on the interaction between Context and ROI for the anterior and the posterior ROIs showed effects of Context from 100 to 500 ms for the anterior ROIs (all Fs > 4.27; p < .05), but not for the posterior ROIs (all ps > .080). No further interactions of Context with Electrode, Hemisphere and/or ROI were obtained.

3.2.3 Discussion Experiment 1

The results for the disambiguating verbs of the S-coordinations embedded in Neutral Context and Biasing Context conditions showed a more positive-going deflection for the verbs in the Biasing Context condition compared to the verbs in the Neutral Context condition from 100 to 400 ms. Likewise, the results for the disambiguating PP of the NP-coordinations in Neutral Context and Biasing Context conditions showed a more positive-going deflection at anterior sites for the Biasing Context condition from 0 to 800 ms. The effects did not resemble any known ERP component in terms of the wave shape, timing and scalp distribution (see General Discussion for further elaboration). For the S-coordination sentences, the ERPs were more positive going for one contra-sign (Biasing Context condition) than for two contra-signs (Neutral Context condition). For the NP-coordination sentences the waveforms were more positive at anterior sites for two contra-signs (Biasing Context condition), but more negative at posterior sites, relative to one contra-sign (Neutral Context condition). These results could be interpreted as a reflection of processing difficulty in the Neutral Context condition for the S-coordination sentences, and in the Biasing Context condition for the NP-coordination sentences.

3.3 Experiment 2: Prosodic structure in line with eventual disambiguation

3.3.1 S-coordinations: Verb in neutral and biasing contexts

Grand average waveforms time-locked to the onset of the uniqueness point of the disambiguating verb of S-coordination sentences with a prosodic break in the Neutral Context and in the Biasing Context condition in Experiment 2 are presented in Figure 3. Inspection of the waveforms may suggest that the waveforms for the Biasing Context condition are more negative going from around 700 to 900 ms (see for example electrodes Cz, P4, and CP6). However, no reliable effects of Context, or interactions of Context and (Midline) Electrode, Hemisphere or ROI were obtained, neither for the midline electrodes, nor for the lateral electrodes (all ps > .10).

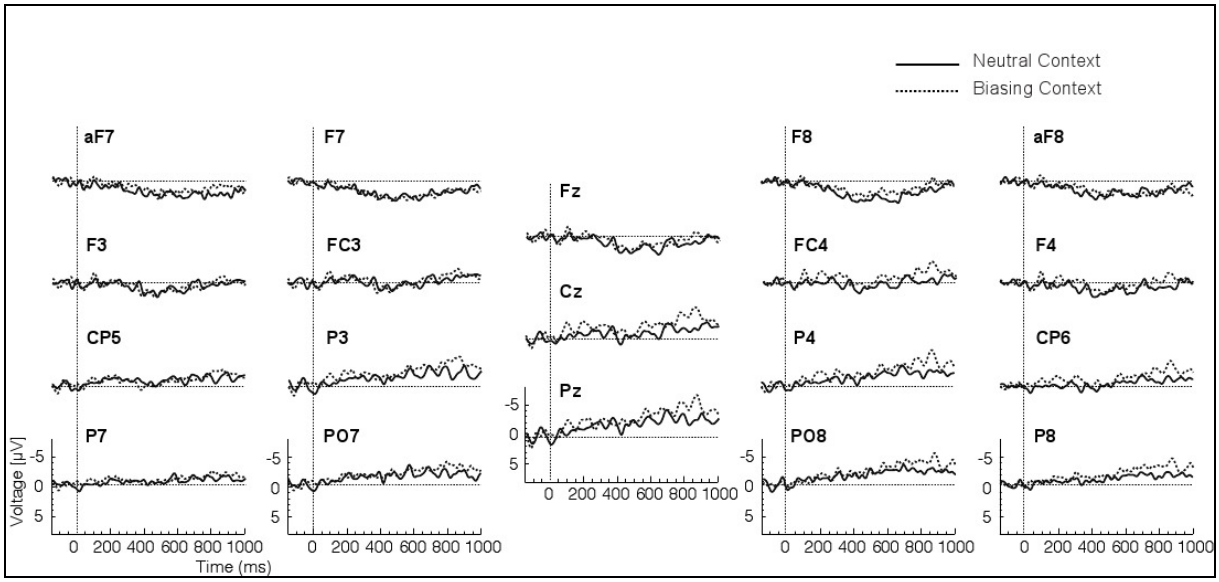


Figure 3: S-coordination sentences with a prosodic break in Experiment 2. Grand average waveforms over participants (n = 30), time-locked to the uniqueness point of the disambiguating verb for the Neutral Context condition (solid line) and the Biasing Context condition (dotted line).

3.3.2 NP-coordinations: PP in neutral and biasing contexts

Grand average waveforms time-locked to the onset of the prepositional phrase for the NP-coordination sentences in the Neutral Context and in the Biasing Context condition in Experiment 2 are presented in Figure 4. Inspection of the waveforms may suggest that the waveforms for the Biasing Context condition are more negative going for the central and posterior midline electrode from about 300 to 600 ms (see Cz and Pz).

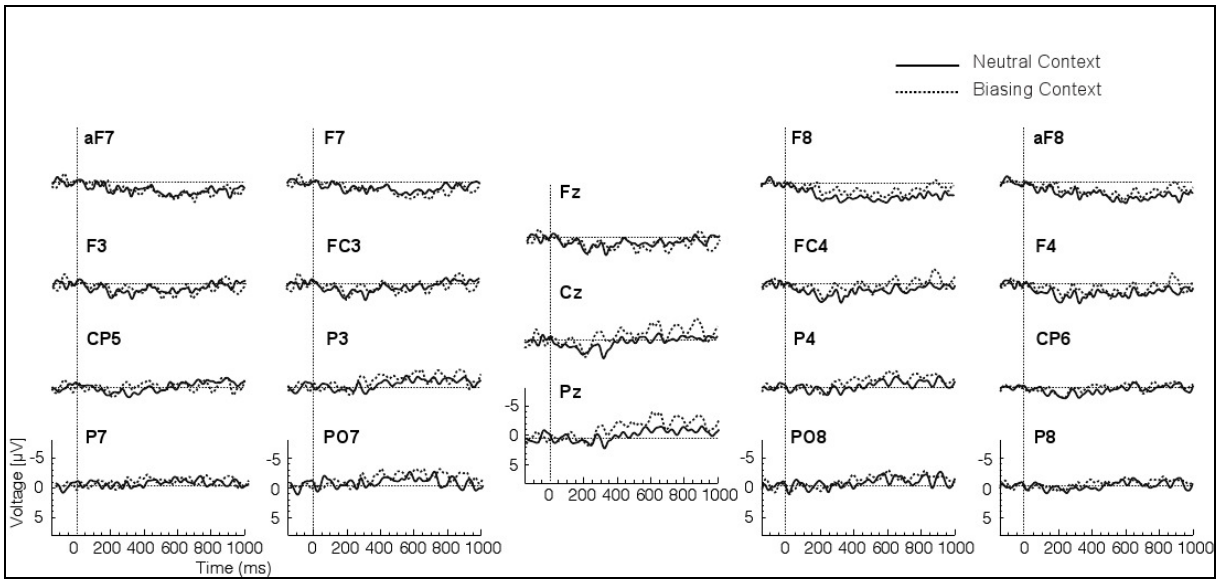


Figure 4: NP-coordination sentences with a prosodic break in Experiment 2. Grand average waveforms over participants (n = 30), time-locked to the onset of the PP for the Neutral Context condition (solid line) and the Biasing Context condition (dotted line).

The time-course analyses revealed an interaction between Context, and Midline Electrode in the 500 to 600 ms window, and in the 700 to 800 ms time-window (both Fs > 3.49; both ps < .05). Additionally, a trend towards an Context by Midline Electrode was found in the 600 to 700 ms window ($F[2, 28] = 3.28$; $p = .055$). However, follow-up analyses for individual electrodes for the significant interactions showed only a trend towards a significant effect of Context for the Pz electrode in the 700 to 800 ms ($t = 2.03$; $p = .055$).

The analyses for the lateral sites did not show main effects of Context (all ps > .10). An interaction between Context, Hemisphere, and ROI was found in the time-windows spanning the 600 to 800 ms epoch (all Fs > 5.10; all ps < .05). However, follow-up analyses for the two levels of ROI and Hemisphere did not yield any effects of Context (all ps > .20).

3.4 Discussion Experiment 2

The main results for Experiment 2 were as follows: First, the data at the disambiguating verb in the Neutral Context condition and the Biasing Context condition showed no differences between the two context conditions. This shows that a prosodic break disambiguates the S-coordination sentences before the onset of the verb, regardless of the context condition in which the sentences are embedded. Second, at the PP no significant differences between the two context conditions were found. This could suggest that the absence of a prosodic break can be a cue for an NP-coordination.

4 General Discussion

This chapter explored the combined effects of contextually induced syntactic expectations and prosodic information on the processing of the syntactically disambiguating region of the coordination sentences. Experiment 1 showed different responses for the Neutral vs. Biasing Context condition both for the S-coordinations and for the NP-coordinations. In contrast,

Experiment 2 did not show any ERP differences, neither for the S-coordination sentences, nor for the NP-coordination sentences.

In both contrasts from Experiment 1, the results did not resemble any standard ERP component associated with syntactic or semantic processing. This failure to find standard ERP-components can be explained as follows. For the S-coordination sentences, the lexically disambiguating verb that was embedded in the Neutral Context condition was contrasted with the lexically disambiguating verb in the Biasing Context condition. In the Neutral Context condition, both the contextually induced expectation and the prosodic information do not signal an S-coordination. By contrast, in the Biasing context condition, the prosodic information does not signal an S-coordination, whereas the contextually induced expectation signals an S-coordination (see Table 1). Thus, the comparison of the lexically disambiguating verb contrasts two-contra signs with one contra-sign. In other words, no standard baseline was available in this contrast (e.g., a baseline without contra-signs which for S-coordination sentences would be sentences with a prosodic break embedded in a biasing context). Likewise, the contrast of the NP-coordination sentences in the Neutral Context condition (one contra-sign) with the NP-coordination sentences in the Biasing Context condition (two contra-signs) does not provide a neutral baseline either. It is likely that the non-standard results found in Experiment 1 are due to the absence of a neutral baseline.

In Experiment 2, no differences were found at the syntactically disambiguating verb of the S-coordination sentences. This indicates that a prosodic break disambiguates the S-coordination sentences before the occurrence of the syntactically disambiguating verb. This conclusion is in line with the results of Chapter 2.

Finally, no differences were found at the PP of the NP-coordination sentences in Experiment 2. This suggests that the absence of a prosodic break was used as a cue to signal an upcoming NP-coordination. If this is the case, the absence of a prosodic break was a cue that was strong enough to override the expectation of an S-coordination in the Biasing Context condition. The results from Supplementary Analyses II showed that the absence of a prosodic break could potentially be a cue. However, another possibility is that the absence of a prosodic break was used strategically. In Experiment 2, a prosodic break always was followed by an S-coordination, whereas the absence of a prosodic break always was followed by an NP-coordination. It is possible that participants learned to interpret the absence of a prosodic break as a cue for an NP-coordination. If this is the case, the absence of a prosodic break would not necessarily be a cue for syntactic continuity, but it would only be so in the context of the present design. Further research will be needed to explore the role of the absence of a prosodic break.

Chapter 5: Conclusion

Looking back at the preceding chapters, two main topics emerge. The first concerns the unexpected difference between visual and auditory processing in isolated sentences. The second concerns the immediate interaction between prosodic information and syntactic information.

1 Visual and auditory processing: Comma and Prosodic Break

The results presented in Chapter 2 showed that the comma in the visual modality in a sentence like (1) did not elicit a CPS. By contrast, the prosodic break in the auditory modality did elicit a CPS. However, both in the visual modality and in the auditory modality, the S-coordination sentences were disambiguated by the comma and the prosodic break, respectively. This shows that, although the comma did not elicit a CPS, the comma must have been processed.

(1) The sheriff protected the farmer(,) and the farm hand defended bravely the ranch against Johnson's gang.

This conclusion is supported by reading time studies (e.g., Hoeks, Vonk, & Schriefers, 2002, and Hoeks et al., 2005) showing that in coordination sentences like (1), reading times (measured via eye-movement registration and self-paced reading) are longer for the word with a comma attached than for the same word without a comma. We are thus confronted with a dissociation between results found with reading time measures and results found with ERP measures. The possibility of such a dissociation suggests that it is advisable to study sentence processing with several measures rather than just focusing on only a single measure.

Why is the processing of a comma reflected directly in reading time measures, and not in the CPS? A first possible explanation can be derived from Steinhauer and Friederici (2001). These authors presented materials with and without a comma to two groups of participants: a group that was high-proficient in punctuation, and a group that was low-proficient in punctuation. For the proficient punctuation group, making no errors on a punctuation test, the comma clearly elicited a CPS. For the low-proficient punctuation group, making one or more errors on a punctuation test, the comma did not elicit a CPS. Steinhauer and Friederici (2001) hypothesized that no CPS was elicited in the low-proficient group because the participants simply did not notice the comma. However, such an explanation cannot account for the present results. As we have seen, the comma was used to disambiguate the S-coordination sentences before the onset of the lexically disambiguating verb. Thus, it cannot be the case that our participants simply did not process the comma.

A second possible explanation relates to the relative saliency of a comma compared to a prosodic break. It could be that only highly salient boundary markers elicit a CPS. This suggestion is supported by a recent MEG study in the auditory modality of Knösche et al. (2005). They observed an MEG correlate of phrase structure in music perception that resembled the CPS in terms of timing and scalp distribution. Source localization suggested that the CPS was elicited in brain structures which have been shown to be involved in memory and attention processes (see General Discussion of Chapter 2 for more details). It could be argued that a prosodic break is perceptually more salient than a comma. If this is the case, and if attention to a cue is necessary to elicit a CPS, a comma might not be salient enough to elicit a CPS. That is, perhaps the comma was not consciously processed, and as such did not give rise to a CPS, but nevertheless was processed without attention to disambiguate the S-coordination sentences.

How does this hypothesis relate to the results of Steinhauer and Friederici (2001)? To account for their results, the comma should be more salient for the high-proficient group than for the low-proficient group. Indirect support for this assumption comes from the fact that their filler materials contained punctuation errors. These errors may have directed the attention of the participants to the punctuation of the critical materials. This effect is likely to be stronger for the high-proficient group than for the low-proficient group. In Dutch, the language used in the present experiments, punctuation rules are very lax compared to German, the language used by Steinhauer and Friederici (2001). It is therefore likely that our Dutch participants resemble the low-proficiency group of Steinhauer and Friederici (2001) more than their high-proficiency group. As a result, no CPS or a reduced CPS is expected in Dutch (see General Discussion of Chapter 2 for details). We will come back to the issue of the relationship between attention and the CPS when discussing the immediate interaction of prosodic information and syntactic information. However, before turning to this issue we add a short methodological note on learning processes and the formation of strategies.

The results of the auditory experiment in Chapter 2 showed different patterns of results in the first half of the experiment and in the second half. In the first half, the lexically disambiguating verb elicited a LAN. In the second half, the lexically disambiguating verb elicited a P600. As discussed in Chapter 2, the LAN has been linked to word category violations, whereas the P600 is generally thought to reflect reanalysis. The changing pattern (first half LAN, second half P600) is likely to reflect a learning process. Initially, in the sentences without a prosodic break, the default NP-coordination expectation holds. As a result, the lexically disambiguating verb is perceived as a word category violation: A verb should not occur at this location. However, during the course of the experiment, the participants learn that an S-coordination is an acceptable continuation of the ambiguous sentences in a proportion of the materials. As a result, what was initially perceived as a word category violation is now perceived as a less severe violation for which the initial NP-coordination interpretation needs to be reanalyzed to a S-coordination interpretation (see the general discussion of Chapter 2 for more details).

Learning processes and/or the formation of strategies presumably play a role in many experiments in psycholinguistics. In the study of sentence processing, for example, participants will not react in the same way to the first occurrence of a particular ambiguity as to the occurrence of an ambiguity after numerous presentations of that same ambiguity. In order to be able to follow such potential changes over the course of the experiment, our experiments were designed such that the first and the second half of the experiment could be analyzed separately. Psycholinguistic experiments should use such designs whenever possible, so that potential learning processes and development of strategies can be traced. The results should then be analyzed with a factor Part of Experiment in order to have a test on the potential formation of strategies by participants.

2 The immediate interaction between prosody and syntax

The second main topic is the immediate interaction between prosodic information and syntactic information. The majority of studies, if not all, in the literature have measured the effects of prosodic information on sentence processing “downstream” one or several words after the actual occurrence of the prosodic information of interest. Take for example the experiments reported in Chapter 2: The effects of the prosodic break were measured several words downstream at the lexically disambiguating verb. In order to measure the immediate interaction between syntactic information and prosodic information in the experiments of

Chapter 3, sentences were embedded into contexts that either induce the expectation of a syntactic break at the potential location of the prosodic break, or did not induce such an expectation. This context manipulation allowed us to align the expectation of syntactic information with the occurrence of prosodic information, and thus to measure the immediate interaction of these two types of information.

As a measure of this immediate interaction, we looked at the CPS in the two context conditions. In the biasing context condition, the prosodic break coincided with the expectation of a syntactic break at the exact same location. By contrast, in the neutral context condition, the prosodic break did not coincide with the expectation of a syntactic break. The results showed that the CPS that was elicited by a prosodic break that coincided with the expectation of a syntactic break was reduced in amplitude relative to the CPS that was elicited by a prosodic break elicited in a context with no such expectation. Because the prosodic break was the same acoustic token in the two context conditions, this difference must have been caused by the preceding context. This result shows that the prosodic information and the contextually induced syntactic expectation interact immediately when they become available. In other words: There is an immediate interaction between prosodic information and syntactic information.

When relating the finding of an immediate interaction between prosodic information and syntactic information to the theories of sentence processing introduced in Chapter 1, it turns out that this result is particularly relevant with respect to one of these theories, Construal. As discussed in Chapter 1, Construal is a special case of syntax-first theories. To allow for non-syntactic information to play a more prominent role in sentence comprehension, the Construal theory hypothesizes that certain syntactic constructions are not immediately interpreted as fixed structures. Instead, the ambiguous part of a sentence become “loosely associated”, rather than attached. This allows for fast reanalysis on the basis of non-syntactic information which does not show up in behavioral or psychophysiological data. But even if we were to assume that the coordination ambiguity is a syntactic construction which allows for such an association, the present data would still be a challenge for this hypothesis: The ambiguous NP, the NP that would need to be associated with the main clause, is not available at the time the interaction is taking place. Therefore, Construal is unable to account for these results. The other two theories (syntax-first theories and interactionist theories) will not be discussed here as the present data shed no new light on these theories.

Having shown that the CPS to the identical prosodic break is modulated by a contextually induced syntactic expectation, the question arises what the CPS reflects. The contextual modulation shows that the CPS is an endogenous component rather than an exogenous component. However, what the CPS actually reflects remains unclear. In the literature, we see that a CPS can be elicited in the visual modality as a response to a comma (Steinhauer & Friederici, 2001). In the auditory modality the CPS is elicited in a wide range of experiments in response to a prosodic break. A CPS is not only elicited by prosodic breaks in normal spoken sentences (Bögels et al., in press; Isel et al., 2005; Kerkhofs et al., 2007; Mietz et al., 2008; Pannekamp et al., 2005; Steinhauer, 2003; Steinhauer et al., 1999; Steinhauer & Friederici, 2001; Toepel et al., 2007)), but also by prosodic breaks in jabberwocky sentences, and by prosodic breaks in delexicalized sentences (Pannekamp et al., 2005, for details see Chapter 1). Additionally, as described above, a magnetic counterpart is also obtained in the processing of musical structure (Knösche et al. 2005). A pattern that is emerging is that the CPS is somehow related to the structuring or segmentation of input with a left-to-right temporal nature (written sentences, speech, music).

Coming back to the issue of the relationship between attention and the CPS, in the discussion of the experiments on sentences in isolation (Chapter 2), we hypothesized that the CPS also has some attentional component. We argued that in the visual modality, the CPS

was eliminated or at least severely reduced because the comma was not salient enough to elicit a clear CPS. This hypothesis is supported by the evidence from Knösche et al. (2005) that the CPS is generated by brain structures associated with attentional processing. How do the findings of the modulation of the CPS by the syntactic expectation relate to this saliency hypothesis? In the experiments on coordination sentences in biasing or neutral contexts we find a mitigated CPS in the conditions where the prosodic break coincides with the expectation of a syntactic break relative to the neutral context condition which does not induce such an expectation. In the light of the saliency hypothesis this would suggest that a prosodic break that coincides with a syntactic break is less salient than a prosodic break that does not coincide with the expectancy of a syntactic break. Although this seems to make sense intuitively, a clarification of the exact relation of expectancy with saliency, and more generally, the exact nature of the CPS and the role of attention in the CPS will need further investigation.

To conclude, the central question that was raised in Chapter 1 of this dissertation was whether syntactic information and prosodic information interact immediately when they become available. The immediate interaction of prosody and syntax only becomes evident when studying the processing of sentences in a discourse context. The experiments that were reported in this dissertation clearly show that syntactic information and prosodic information interact immediately when they become available. This shows that different sources of information like discourse context, prosody and syntax play an immediate role in sentence comprehension.

Appendix I: On alignment points of ERP averaging in auditory language processing

1 Introduction

Chapter 2 (Experiment 2) and Chapter 4 reported the data at the disambiguating region for auditory presented coordination sentences. In these chapters, the ERPs were computed time-locked to the theoretical uniqueness point of the disambiguating verb. The theoretical uniqueness point was chosen as the alignment point because of the left-to-right temporal nature of the speech signal. Contrary to the visual modality, words in the auditory modality spread out over time. As a result, different words will be recognized at different points in time. Verbs with an early uniqueness point (e.g., 'gooide' *threw*, which can in principle be recognized at the second phoneme) are recognized earlier than verbs with a late uniqueness point (e.g., 'doofde' *put out the fire*, which can only be recognized at the penultimate phoneme).

Using the onset of an auditory word to time-lock the waveforms introduces undesirable jitter in the signal. As a result, the ERP components time-locked to the onset of the verb will be more smeared out in time. Using the uniqueness point reduces this problem (Van Berkum, 2003, Van den Brink, Brown, & Hagoort, 2001, Van Petten et al., 1998). There is also evidence that differences in uniqueness points lead to different time-courses of ERP effects when comparing words with early uniqueness points to words with late uniqueness points. Woodward et al. (1990) recorded ERPs to words in a memory task in which old versus new items had to be discriminated. They found that the latency of the N2 to new words correlated both with the duration of these words, and with the position of the uniqueness point of these words. The N2 peaked earlier for short words and words with an early uniqueness point, relative to long words and words with a late uniqueness point. More recently, O'Rourke and Holcomb (2002) presented listeners with spoken stimuli with early and late uniqueness points in a passive listening task. They found that words with early and late uniqueness points elicited very similar N400 patterns when they were time-locked to these uniqueness points. However, when they aligned the signals to the onset of the words, words with early uniqueness points elicited an earlier N400 than words with later uniqueness points (O'Rourke & Holcomb, 2002).

In order to explore the effects of the alignment point that is used to time-lock the signals, the waveforms time-locked to the onset of the disambiguating verb and to the offset of the disambiguating verb were analyzed in addition to the theoretical uniqueness point as time-locking point. This appendix will report the data from the first experiment of Chapter 4.

2 Methods

As described in Chapter 2, the theoretical uniqueness point was determined using the phonological representations from the CELEX database (Baayen et al., 1993). The verbs were matched against a database of words from those syntactic categories that could form a syntactically well-formed continuation of the sentence, but which did not lead to an S-coordination structure. The database contained all plural verbs, present tense verbs, all nouns,

all determiners, and all infinitives. The uniqueness point was defined as the point at which the verb shares no more phonemes with another word in this database. On average, the duration of the disambiguating verb was 353 ms. The duration from the onset of the disambiguating verb to the onset of the uniqueness point of the verb was 198 ms (standard deviation 77 ms, minimum 49 ms and maximum 391 ms). The duration from the uniqueness point of the disambiguating verb to the offset of the verb was 155 ms (standard deviation 114 ms, minimum 0 ms and maximum 536 ms).

3 Results

The analyses for the midline sites and for the lateral sites were identical to those performed for the uniqueness point of the disambiguating verb in Chapter 4. Time-course analyses were performed using consecutive 100 ms time-windows from 0 to 1000 ms after either the onset of the first phoneme of the verb, or the offset of the last phoneme of the verb.

3.1 Onset Verb

Grand average waveforms time-locked to the onset of the disambiguating verb of the S-coordination sentences in Neutral Context and in Biasing Context conditions are presented in Figure 1. Inspection of the waveforms suggests that the waveforms for the Biasing Context condition are more positive going for the midline electrodes for the entire 1000 ms epoch (see for example Cz and Pz). The analyses for the midline sites showed an effect of Context from 200 to 600 ms (all $Fs > 4.30$; all $ps < .05$). The interaction between Context and Midline Electrode was not significant in any of the time-windows (all $ps > .15$). The analyses for the lateral sites showed a main effect of Context from 200 to 600 ms (all $Fs > 4.30$; all $ps < .05$). In addition, the interaction between Context and Hemisphere was significant from 200 to 1000 ms (all $Fs > 6.51$; all $ps < .05$). Separate analyses for both levels of Hemisphere revealed main effects of Context for the left hemisphere from 200 to 800 ms (all $Fs > 3.99$; all $ps < .05$). For the right hemisphere, no effects of context were found in any of the windows between 200 and 1000 ms (al $Fs < 1$), except for the 400 to 500 ms window ($F[1, 29] = 7,24$; $p < .05$).

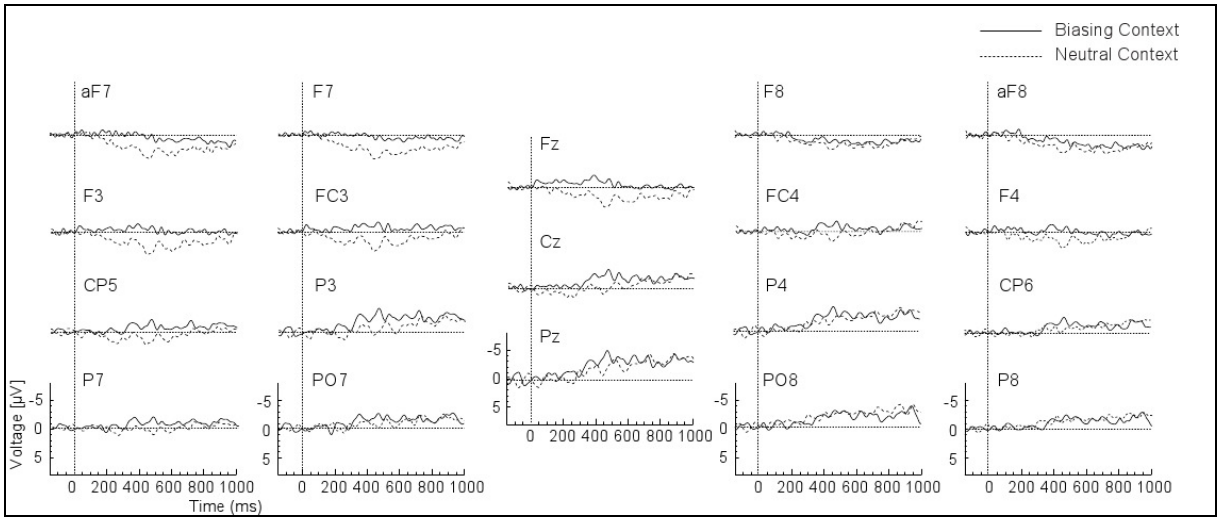


Figure 1: Grand average waveforms over participants (n = 30), time-locked to the onset of the disambiguating verb, for the No Prosodic Break in Neutral Context condition (solid line) and the Prosodic Break in Neutral Context condition (dotted line) in Experiment 1 of Chapter 4.

3.2 Offset Verb

Grand average waveforms time-locked to the offset of the disambiguating verb of the S - coordination sentences in Neutral Context and in Biasing Context conditions are presented in Figure 2. Inspection of the waveforms suggests that the waveforms for the Biasing Context condition do not differ in the entire 1000 ms epoch (see for example Cz and Pz). In line with this, the analyses for both the midline sites and the lateral sites did not show effects of Context (all ps > .10). In addition no interactions between Context and Midline Electrode (all ps > .10), or between Context, Hemisphere, ROI, and/or Electrode were obtained (all ps > .20).

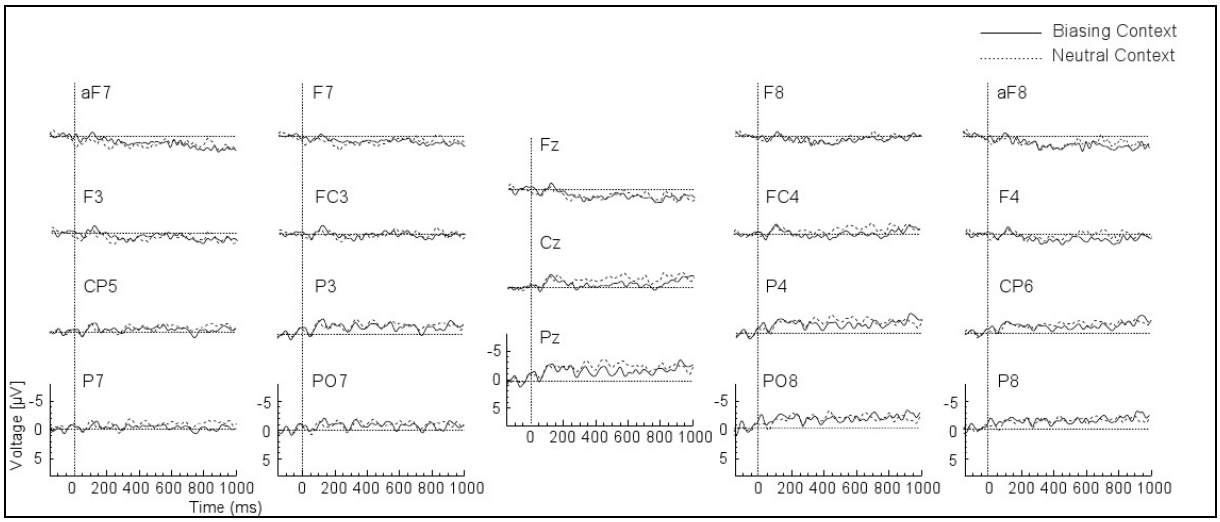


Figure 2: Grand average waveforms over participants (n = 30), time-locked to the offset of the disambiguating verb, for the No Prosodic Break in Neutral Context condition (solid line) and the Prosodic Break in Neutral Context condition (dotted line) in Experiment 1 of Chapter 4.

4 Discussion

In the present section we explored the effect of different alignment points used to time-lock the ERP-signals. Clear differences between the onset and the offset of the verb were obtained. For the onset of the verb, a more positive going deflection for the biasing context condition lasting from 200 to 800 ms was found relative to the neutral context condition. By contrast, for the offset of the verb, no effects were found.

When using the onset of the verb as time-locking point, we already find significant differences between the context conditions after only 200 ms. Although this seems very early, note that there is inevitable variance in the precise determination of where a spoken word begins (see also Van Berkum et al., 2003). Due to general and language specific constraints on pronunciation, phonemes of a preceding word contain co-articulatory cues concerning the initial phonemes of the word following this word. Using the onset of the first phoneme of a word, or using the uniqueness point of a word to time-lock the signal without taking into account this co-articulation, may result in effects with an earlier onset, because the factual (i.e., empirical) recognition points in continuous speech may arise earlier than those based on phonemic transcriptions.

At the offset of the verb, no effects were obtained. The reason for this can be two-fold. First, in principle the effect of the syntactic disambiguating verb could be gone by the time we get to the offset of the disambiguating verb. However, in Chapter 4 we have shown an effect that lasted from 100 to 400 ms. Since there are on average only 155 ms between the uniqueness point and the offset of the verb it is clearly not the case that the effects could have already vanished. A second possibility is that no differences between the two context conditions are found at verb offset because the signals are normalized at a point where there is already a significant difference between the conditions. In the normalizing procedure, the signals are shifted along the voltage axis in such a way that the average amplitude is zero μV on average in a time-window of 150 ms preceding the point used for time-locking. It is possible that the long-lasting effect found at the onset and at the uniqueness point of the verb is reduced to zero when using verb-offset for time-locking, since the time-window used for normalization falls within the time-course of this effect.

To conclude, the present data show that the choice of the alignment point can have a major impact on the results. Although for the present data set, the results at the onset of the verb and at the theoretical uniqueness point did not differ much, aligning and normalizing the data too early or too late may result in undesirable jitter in the signal, the wrong time-course of effects, or may even result in the absence of effects. Choosing the theoretical uniqueness point of a word for time-locking the signals provides an easy, not too time-consuming, and relatively accurate way to deal with the inevitable variance of the signal in the auditory modality. It appears to provide the best compromise between either using the onset or offset of a word for time-locking, or determining the actual empirical uniqueness point of a word.

Appendix II: Experimental materials used in Chapter 2

Appendix II presents the Dutch target sentences (S-coordination sentences) and NP-coordination experimental filler sentences. These sentences were used in the visual modality (Experiment 1 from Chapter 2), and in the auditory modality (Experiment 2 from Chapter 2). The experimental manipulation in the target sentences, ambiguous S-coordination sentences versus unambiguous S-coordination sentences, is denoted by the comma between parantheses. In the visual modality, the S-coordination sentences were disambiguated by a comma. In the auditory modality the S-coordination sentences were disambiguated by a prosodic break at the position of the comma.

S-coordinations:

1. De voorzitter bedankte de sponsor(,) en de trainer bestelde lachend een biertje voor alle aanwezigen.
2. De mannequin kuste de ontwerper(,) en de fotograaf pakte vrolijk een fles bruisende champagne en wat kaviaar.
3. De rector ondervroeg de leraar(,) en de leerling volgde stiekem het verhitte gesprek vanaf de gang.
4. De gevangene gijzelde de priester(,) en de bewaker riep geschrokken zijn collega's die gehaast aan kwamen lopen.
5. De weduwe bedankte de organist(,) en de predikant bekeek aandachtig de menigte mensen die was gekomen.
6. De bedrijfsleider kalmeerde de gast(,) en de ober bracht mopperend het bord weer naar de keuken.
7. De redacteur prees de fotograaf(,) en de journalist bekeek bewonderend de foto's van de vluchtelingenkampen.
8. De sheriff beschermde de boer(,) en de knecht verdedigde wanhopig de boerderij tegen Johnson's bende.
9. De grimeur schminkte de schrijver(,) en de interviewer besprak kort de vragen die hij wilde stellen.
10. De verdachte beledigde de rechter(,) en de advocaat belde ontstemd het kantoor waar hij werkte.
11. De eigenaar prees de kok(,) en de ober floot zachtjes een liedje met een vrolijke melodie.
12. De dirigent bekritiseerde de cellist(,) en de pianist smeet boos zijn volledige partituur op de grond.
13. De portier bespioneerde de chef(,) en de secretaresse belde heimelijk de politie om aangifte te doen.
14. De dief beschoot de juwelier(,) en de agent riskeerde moedig zijn leven door de dief te ontwapenen.
15. De regisseur bespotte de nieuwslezer(,) en de weerman vervloekte kwaad de opzet van het nieuwe programma.
16. De winnares omhelsde de sponsor(,) en de trainer groette enthousiast het publiek op de tribune.
17. De rechter berispte de verdachte(,) en de advocaat bedacht snel een reden om de zitting te verdagen.
18. De presentator introduceerde de schrijver(,) en de criticus maakte grijnzend een buiging naar het publiek.
19. De stalker achtervolgde de danseres(,) en de manager opende vlug de deur van de gereedstaande limousine.
20. De politieman ondervroeg de koerier(,) en de infiltrant achterhaalde later de naam van de opdrachtgever.
21. De gravin wenkte de koetsier(,) en de lakei droeg zuchtend de koffers naar de gereedstaande koets.
22. De presentator omarmde de zanger(,) en de zangeres zong huilend de beginregels van hun eerste hit.
23. De hulpverlener informeerde de arts(,) en de brandweerman bevrijdde gehaast het slachtoffer uit de brandende auto.
24. De tovenaar bewaakte de koningin(,) en de prinses haalde gauw het toverboek uit de magische bibliotheek.
25. De voorbijganger bevrijdde het kind(,) en de vrouw schreeuwde hysterisch de longen uit haar lijf.
26. De boswachter berispte de padvinder(,) en de hopman doofde gauw het vuurtje met wat scheppen zand.
27. De toerist fotografeerde de visser(,) en de reisleider vertelde gedreven een verhaal over de visserij in de streek.
28. De dichter bezong de zwerver(,) en de dronkaard prees luidkeels de schoonheid van de Amsterdamse grachten.
29. De professor belde de aannemer(,) en de architect eiste direct een onderzoek door een onafhankelijk bureau.
30. De klant bedankte de bedrijfsleider(,) en de bediende vroeg meteen de kassabon om de trui te ruilen.
31. De lerares begroette de leerling(,) en de moeder beschreef uitvoerig de thuissituatie van het problematische kind.
32. De pastoor zegende de stuurman(,) en de kapitein bedankte lachend de geestelijke voor zijn goede zorgen.
33. De chauffeur vervoerde de baron(,) en de butler bracht keurig de bagage naar het kasteel.

34. De actrice vervloekte de stuntman(,) en de producent gooide woedend zijn dikke sigaar op de grond.
35. De burgemeester ondervroeg de leraar(,) en de onderzoeker onderkende zakelijk de voordelen van het nieuwe onderwijsplan.
36. Het Kamerlid bespotte de interviewer(,) en de minister herhaalde minachtend de vragen die hem gesteld waren.
37. De lijfwacht beschermde de president(,) en de generaal beval direct zijn troepen de omgeving te doorzoeken.
38. De automobilist raakte de voetganger(,) en de fietser verloor geschrokken zijn evenwicht waardoor hij op straat viel.
39. De tuinman bespiedde het dienstmeisje(,) en de butler pakte meteen een verrekijker om haar te kunnen bekijken.
40. De clown ontvluchtte de goochelaar(,) en de acrobaat beklom vlug de ladder naar de nok van de tent.
41. De suppoost waarschuwde de student(,) en de studente stopte snel de camera in haar tas.
42. De psychiater observeerde de patiënt(,) en de assistent noteerde zorgvuldig de medische gegevens in het dossier.
43. De huisvrouw zoende de kennis(,) en het kind bekeek nieuwsgierig de mensen die langs hen heen liepen.
44. De directeur ontsloeg de werknemer(,) en de chef riskeerde vervolgens zijn baan door hiertegen te protesteren.
45. De burgemeester loofde de wethouder(,) en de ondernemer liet meteen een fles Franse cognac bezorgen.
46. De koningin beloonde de lakei(,) en de hofdame kreeg onmiddellijk een rode kleur van opwinding.
47. De reiziger vervloekte de piloot(,) en de stewardess verzorgde keurig een passagier die zijn hoofd gestoten had.
48. De chirurg troostte de man(,) en de vrouw legde bezorgd haar hand op zijn warme voorhoofd.
49. De astronaut groette de technicus(,) en de monteur opende behoedzaam de sluis van de gereedstaande raket.
50. De fan belaagde de drummer(,) en de gitarist riep ontzet de beveiliging die al paraat stond.
51. De commissaris bedreigde de parkeerwacht(,) en de rechercheur vertrok woedend waarbij hij de deur dichtsmeet.
52. De archeoloog betaalde de indiaan(,) en de graver stopte netjes alle spullen in een grote koffer.
53. De dichter belaagde de criticus(,) en de redacteur besloot meteen een uitvoerige rectificatie te plaatsen.
54. De verpleger verschoonde de junk(,) en de zwerfster waste mopperend haar gezicht met water en zeep.
55. De kapelaan vermaande de koorknaap(,) en het hulpje wist nauwelijks zijn lachen te bedwingen.
56. De medicijnman besprenkelde de bezetene(,) en het opperhoofd goot voorzichtig olie over het vreemde masker.
57. De priester offerde de slavin(,) en de slaaf bewierookte dromerig het stenen beeld van de godheid.
58. De volgeling vereerde de goeroe(,) en de ingewijde luisterde ademloos naar zijn gepassioneerde toespraak.
59. De activist besmeurde de lijfwacht(,) en de officier morste onoplettend koffie op zijn smetteloze uniform.
60. De fakir betoverde de toeschouwer(,) en de danseres vertoonde geamuseerd haar sensuele buikdans op de markt.

NP-Coordinations:

61. De schoonvader feliciteerde de bruid en de bruidegom in het stadhuis met hun feestelijke bruiloft.
62. De journalist interviewde de kraker en de agent op de Dam waar hevige rellen bezig waren.
63. De klant beledigde de bewaker en de verkoper in een ruzie om een beschuldiging van diefstal.
64. De brandweerman redde de conciërge en de scholier uit de school voordat die half afgebrand was.
65. De dokter ondersteunde de notaris en de pastoor naar de uitgang van het café op de markt.
66. De moeder troostte de baby en het meisje in het warenhuis waar zij veel herrie maakten.
67. De chirurg overtuigde de zieke en de internist in een gesprek dat op het ziekenhuis plaatsvond.
68. De zuiplap vergaf de leverancier en de kroegbaas op het terras aan de grote markt.
69. De winkelier betaalde de timmerman en de metselaar voor de schuur die zij voor hem gebouwd hadden.
70. De ridder bevrijdde de jonkvrouw en de dienares uit het hol van de gevaarlijke draak.
71. De boekhouder complimenteerde de stagiair en de telefoniste op het feestje omdat zij mooi gekleed waren.
72. De ambassadeur begeleidde de president en de tolk uit de vergaderkamer van het indrukwekkende regeringsgebouw.
73. De zieke raadpleegde de medicijnman en het stamhoofd uit het dorp aan de rand van het bos.
74. De jongeman gehoorzaamde de imam en de dorpsoudste in het besluit dat hij zijn nicht moest trouwen.
75. De hofnar feliciteerde de koning en de maarschalk in de troonzaal van het kasteel met hun overwinning.
76. De scheidsrechter bestrafte de keeper en de aanvoerder met een kaart vanwege hun brutale gedrag.
77. De oppas zoende het jongetje en het meisje op hun hoofdjes en stopte ze in bed.

78. De quizmaster omhelsde de deelnemer en de assistente in de uitzending toen ze de dure auto wonnen.
79. De directeur bewonderde de schilder en de beeldhouwer uit de commune die ergens in Frankrijk leefde.
80. De student haatte de hospita en de huisgenoot van het huis waar hij onlangs uit is vertrokken.
81. De sheriff zag de indiaan en de cowboy achter een rotspunt die scherp tegen de lucht afstak.
82. De dansleraar volgde de beheerder en de cursist in het gebouw waar hij de weg niet kende.
83. De detective schaduwde de industrieel en de secretaresse in het donker omdat hij hun relatie wilde onthullen.
84. De getuige beschreef de tasjesdief en de straatrover op het politiebureau waar hij ondervraagd werd.
85. De ambtenaar bezocht de boer en de boerin in het dorpje dat onder zijn verantwoordelijkheid viel.
86. De dokter begroette de patiënt en de verpleegster in de gang waar hij hen tegenkwam.
87. De regisseur kalmeerde de actrice en de cameraman op de set omdat iedereen overstuur begon te raken.
88. De tekenaar tekende de wandelaar en de strandjutter bij de vloedlijn op het winderige strand.
89. De padvinder zag de stroper en de boswachter voor de hut lopen en rende er op af.
90. De fraudeur sloeg de buurman en de beambte op het politiebureau omdat zij hem hadden aangegeven.
91. De kleuter riep de postbode en de melkman op een manier die hen lachend deed omkijken.
92. De paus verwelkomde de kardinaal en de bisschop in de tuin van zijn rustige buitenverblijf.
93. De ondernemer bezocht de geldschieter en de notaris uit de stad om een voordelige lening te krijgen.
94. De toerist fotografeerde de junk en de straatmuzikant in het straatje dat er zo schilderachtig uitzag.
95. De componist instrueerde de percussionist en de violist in de ruimte waar ze een laatste repetitie hadden.
96. De demonstrant bekogelde de minister en de ambtenaar op het plein in het centrum van de stad.
97. De troubadour bezong de vorst en de maîtresse in de rozentuin waar zij een wandeling maakten.
98. De milieuwachter bekeurde de schilder en de loodgieter achter de schuur waar ze de verf gedumpt hadden.
99. De dictator wantrouwde de generaal en de adjudant van het leger omdat hij nogal paranoïde was.
100. De reiziger volgde de drager en de gids op de berg die ze aan het beklimmen waren.
101. De makelaar ontving de koper en de verkoper op zijn kantoor om het voorlopige koopcontract te tekenen.
102. De portier waarschuwde de voorzitter en de penningmeester in de vergadering omdat er een dringend bericht was.
103. De bejaarde beschimpte de arts en de verzorgster in het verpleeghuis omdat zij hem kinderachtig behandelden.
104. De kleuter bewonderde de conducteur en de machinist in de trein vanwege hun mooie uniformen.
105. De crimineel verlinkte de medeplichtige en de opdrachtgever in de gevangenis omdat hij bang was.
106. De schipper vervloekte de stuurman en de bootwerker op zijn boot toen de lading opnieuw viel.
107. De veilingmeester ontmoette de curator en de antiquair in het museum bij de onthulling van het schilderij.
108. De staker bekogelde de vakbondsman en de mijnwerker in de bus omdat hij zich bedrogen voelde.
109. De automobilist beschuldigde de monteur en de garagehouder in de garage van het beschadigen van zijn autolak.
110. De wielrenner riep de verzorger en de coach op de tribune omdat hen veel eer toekwam.
111. De econoom waarschuwde de belegger en de speculant in het gesprek over de naderende recessie.
112. De kapitein zag de matroos en de piraat op het dek gespannen vechten voor hun leven.
113. De aannemer riep de grondwerker en de chauffeur uit de vrachtwagen omdat zij aan het werk moesten.
114. De bokser sloeg de scheidsrechter en de tegenstander in de ring waar ze hooglopende ruzie hadden gekregen.
115. De schaatser belde de haptonoom en de masseur in het sportcentrum waar hij voor de wedstrijd trainde.
116. De hertog bevocht de prins en de ridder in een geschil over een belangrijk landgoed.
117. De moeder schreef de mentor en de rector over het gedrag van haar zoon die geschorst was.
118. Het rotjoch schopte de pastoor en de misdienaar in de kerk omdat zij hem brutaal noemden.
119. De sultan verbande de rebel en de schildwacht naar een eiland in de Stille Zuidzee.
120. De conducteur bekeurde de puber en de manager in de trein toen ze weigerden te betalen.

Appendix III: Experimental materials used in Chapter 3 and Chapter 4

Appendix III presents the Dutch items that were used to construct the auditory stimulus materials in Chapters 3 and 4. The structure of each item is as follows. Each item starts with a lead-in sentence (the sentence preceding the parentheses). The second sentence is used for the context manipulation. It is either an S-coordination biasing sentence (the first of the two sentences between parentheses) or a neutral sentence (the second of the two sentences between parentheses). Directly following the context sentence, the target sentence is presented (shown in italics). Finally, each item ends with one or two exit sentences. All these items were recorded by a speaker and presented auditorily (see Materials section of Chapter 3 for a description of the auditory materials). The target sentences either contained a prosodic break, or did not contain a prosodic break (denoted by (//)). In Experiment 1 of Chapter 3 and 4, the S-coordination sentences did not have a prosodic break, whereas the NP-coordination sentences did have a prosodic break. In Experiment 2 of Chapter 3 and 4 the reverse held: The S-coordination sentences contained a prosodic break, whereas the NP-coordination sentences did not contain a prosodic break.

S-Coordinations

1.

Dankzij de goede resultaten van de afgelopen tijd kon de voetbalclub op een verdubbeling van de sponsorgelden rekenen. (Toen ze de sponsor het goede nieuws hoorden vertellen, waren de voorzitter en de trainer erg blij. / Toen het goede nieuws bekend werd gemaakt, ontstond er een opperbeste stemming op de bijeenkomst.) *De voorzitter bedankte de sponsor (//) en de trainer bestelde lachend een biertje voor alle aanwezigen.* Uren later zat de kantine, waar de bijeenkomst gehouden was, nog vol met mensen.
Het bier vloeide rijkelijk die avond.

2.

De nieuwe collectie avondjurken, die op die avond gepresenteerd werd, sloeg in als een bom in de Parijse modewereld. (Toen ze de ontwerper na afloop op het feest spraken, waren de mannequin en de fotograaf dan ook heel enthousiast. / Het was dan ook niet vreemd dat het feest naderhand bijzonder uitbundig was.) *De mannequin kuste de ontwerper (//) en de fotograaf pakte vrolijk een fles bruisende champagne en wat kaviaar.* Alle aanwezigen spraken hun bewondering uit voor de jurken. Het werd een onvergetelijke avond.

3.

Op het Petrus Canisius College ging er dit jaar iets mis bij het eindexamen Nederlands. (Omdat ze de leraar van slordige fouten verdachten, wilden de rector en de leerling de zaak tot op de bodem uitzoeken. / Om duidelijkheid te brengen in de situatie, werd er een onderzoek ingesteld.) *De rector ondervroeg de leraar (//) en de leerling volgde stiekem het verhitte gesprek vanaf de gang.* Het eindresultaat was dat de leerling toch een herkansing kreeg. De leraar Nederlands stemde daar mopperend mee in.

4.

De gouverneur van Texas had het gratieverzoek niet ingewilligd. (Toen ze de priester de cel binnen zagen komen om het nieuws te brengen, waren de gevangene en de bewaker tot het uiterste gespannen. / Het bericht van de gouverneur bereikte de dodencel voor de avondmis in de gevangeniskerk.) *De gevangene gijzelde de priester (//) en de bewaker riep geschrokken zijn collega's die meteen aan kwamen lopen.* Na een anderhalf uur durende gijzeling werd de gevangene door een scherpschutter buiten gevecht gesteld. De gouverneur heeft laten weten een onderzoek in te zullen stellen.

5.

De begrafenisdienst was druk bezocht. (Toen ze de organist na de dienst het gemeenschapshuis binnen zagen komen, stonden de weduwe en de predikant nog steeds handen te schudden. / Toen de laatste klanken van het kerkorgel vervlogen waren, stroomde de ontvangstruimte langzaam vol.) *De weduwe bedankte de organist (//) en de predikant bekeek aandachtig de menigte mensen die was gekomen.* Ruim een uur later was de condoleance nog niet afgelopen. De familie was verrast door de grote belangstelling.

6.

In het goedkope restaurant kwam het regelmatig voor dat er gezeurd werd over het eten. (Toen zij de klant kwaad op hen af zagen stevenen, konden de bedrijfsleider en de ober hun irritatie nauwelijks bedwingen. / Toen er ook nu klachten kwamen over het hoofdgerecht, ontstond er bij tafel drie een heftige woordenwisseling.) *De bedrijfsleider kalmeerde de klant (//) en de ober bracht mopperend het bord weer naar de keuken.* Gelukkig nam de klant genoegen met een flesje wijn van het huis. De bedrijfsleider zuchtte maar weer eens diep.

7.

Het Parool was kritisch in de beoordeling van reportages, zo moesten de foto's altijd een mooi geheel vormen met de tekst. (Nadat zij de fotograaf zijn werk hadden laten presenteren, lieten de redacteur en de journalist hun waardering duidelijk blijken. / Nadat het artikel over Afrika in concept klaar was, werd het tijdens de vergadering uitgebreid besproken.) *De redacteur prees de fotograaf (//) en de journalist bekeek bewonderend de foto's van de vluchtelingenkampen.* Niet lang daarna ontving Het Parool in Kopenhagen de prestigieuze Prix Stendhal 1997 voor de mooie serie artikelen. Voor de jonge fotograaf was dit een geweldige start van zijn carrière.

8.

Nog geen dag nadat James 'Mad Dog' Johnson was ontsnapt, was het alweer raak in Painful Gulch. (Toen ze de boer om hulp hoorden roepen, snelden de sheriff en de knecht onmiddellijk naar de boerderij. / Toen Johnson zijn mannen weer opgetrommeld had, was de grootste boerderij in de buurt het doelwit van hun actie.) *De sheriff beschermde de boer (//) en de knecht verdedigde wanhopig de boerderij tegen Johnson's bende.* Na een vuurgevecht dat drie kwartier duurde kwam er uiteindelijk versterking voor de sheriff. Zo kon James Johnson dezelfde dag weer achter de tralies worden gezet.

9.

TV Gelderland zou die avond een literatuurprogramma uitzenden over het boek 'Avondschemering', dat al voor veel ophef had gezorgd. (Toen ze de schrijver in de kleedkamer zagen zitten, gingen de grimeur en de interviewer er meteen heen. / Omdat het programma live uitgezonden zou worden, heerste er een zekere spanning in de kleedkamer, waar iedereen toonbaar gemaakt werd.) *De grimeur schminkte de schrijver (//) en de interviewer besprak kort de vragen die hij wilde stellen.* Gelukkig hadden ze nog een uur voordat de uitzending zou beginnen. De goede voorbereiding loonde de moeite, want het werd een erg goed interview.

10.

Iedereen had verwacht dat het vrijspraak zou worden, maar het vonnis luidde: drie maanden celstraf, onvoorwaardelijk. (Toen ze de rechter de zaal zagen verlaten, werden de verdachte en de advocaat echt kwaad. / Toen het vonnis uitgesproken werd, ontstond er grote consternatie in de rechtszaal.) *De verdachte beledigde de rechter (//) en de advocaat belde ontstemd het kantoor waar hij werkte.* Deze uitspraak zou zeker aangevochten worden. In hoger beroep werd de verdachte alsnog vrijgesproken.

11.

Het was die avond wel even spannend of het restaurant zijn reputatie nog waar kon maken, zeker na al die personeelswisselingen van de laatste tijd. (Toen ze de kok erg zijn best zagen doen, waren de eigenaar en de ober verheugd. / Toen bleek dat de gasten het eten heerlijk vonden, verdween alle spanning als sneeuw voor de zon.) *De eigenaar prees de kok (//) en de ober floot zachtjes een liedje met een vrolijke melodie.* De kok werd zelfs nog binnengeroepen om de complimenten van de gasten in ontvangst te nemen. Iedereen was heel tevreden met de vlotte gang van zaken.

12.

De uitvoering van het moderne concertstuk was erbarmelijk geweest. (Toen ze de cellist naar de kleedkamer volgden, waren de dirigent en de pianist woedend over de slechte uitvoering. / Toen aan het einde bijna niemand had geapplaudisseerd, heerste er in de kleedkamer een bedrukte stemming.) *De dirigent bekritiseerde de cellist (//) en de pianist smeet boos zijn volledige partituur op de grond.* Geregeld kwamen er knallende ruzies voor in de kleedkamer. Vreemd genoeg bleef dit ensemble nog ruim een jaar optreden in schouwburgen door het hele land.

13.

Bij Bang & Olufsen werd nog al eens wat gestolen, niet in de laatste plaats omdat het bedrijf bijzondere audioapparatuur maakte. (Toen ze de chef van diefstal verdachten, werden de portier en de secretaresse helemaal nieuwsgierig. / Toen bekend werd dat er op grote schaal spullen verdwenen, werd de sfeer in het bedrijf er niet beter op.) *De portier bespioneerde de chef (//) en de secretaresse belde heimelijk de politie om aangifte te doen.* Ze zagen namelijk dat de chef dozen uit het magazijn in zijn auto zette. Later bleek dat de chef al vaker voor veel geld gestolen had.

14.

Bij de overval op de juwelierszaak was er gelukkig een patrouillewagen in de buurt. (Toen ze de juwelier een knuppel tevoorschijn zagen halen, reageerden de dief en de agent meteen. / Toen het alarm plotseling begon te loeien, escaleerde de situatie in de winkel.) *De dief beschoot de juwelier (//) en de agent riskeerde moedig zijn leven door de dief te ontwapenen.* De aangerukte versterking rekende de overvaller even later in. Gelukkig was er niemand gewond geraakt door de rondvliegende kogels.

15.

Er was veel tijd en moeite besteed aan het moderniseren van het nieuwsprogramma. (Toen ze de nieuwslezer de ene fout na de andere zagen maken, schudden de regisseur en de weerman geërgerd het hoofd. / Toen het nieuwe journaal voor het eerst op televisie werd uitgezonden, werd er in de studio echter veel kritiek op gegeven.) *De regisseur bespotte de nieuwslezer (//) en de weerman vervloekte kwaad de opzet van het nieuwe programma.* Ook bleek uit de kijkcijfers dat een hoop mensen het programma niet had afgekeken. Toch bleef de nieuwe formule gehandhaafd.

16.

Niemand had gedacht dat de 400 meter voor vrouwen in de ABN-AMRO atletiekcompetitie zo'n succes zou worden. (Toen ze de sponsor bij het podium zagen, liepen de winnares en de trainer er meteen heen. / Toen het wereldrecord verbroken werd, was het hele stadion uitzinnig van vreugde.) *De winnares omhelsde de sponsor (//) en de trainer groette enthousiast het publiek op de tribune.* Bij de prijsuitreiking stond de winnares huilend op het podium. Wat een ongelooflijke prestatie!

17.

Het lijkt soms wel onmogelijk om in een rechtszaak achter de ware toedracht van een misdrijf te komen. (Toen ze de verdachte geen duidelijk antwoord hoorden geven, keken de rechter en de advocaat elkaar vertwijfeld aan. / Toen de rechtszitting uit de hand dreigde te lopen, klonk er verontwaardigd geroezemoes vanuit de zaal.) *De rechter berispte de verdachte (//) en de advocaat bedacht snel een reden om de zitting te verdagen.* Inderdaad werd deze kort daarna geschorst. Het zou nog twee weken duren voordat de volgende zitting was.

18.

Het programma over kunst en cultuur trok ondanks het late tijdstip altijd veel kijkers. (Aangezien ze de schrijver aan een diepgaand interview wilden onderwerpen, waren de presentator en de criticus licht gespannen. / Deze avond stond er een discussie over het Boekenweekgeschenk centraal.) *De presentator introduceerde de schrijver (//) en de criticus maakte grijnzend een buiging naar het publiek.* Tijdens de verhitte discussies moest het publiek vaak lachen om de cynische opmerkingen van de criticus. In de volgende uitzending zou Rudi van Dantzig iets vertellen over zijn nieuwe dansvoorstelling.

19.

De dansvoorstelling van het beroemde duo was een daverend succes. (Toen ze de danseres na afloop van de voorstelling weg zagen glippen, kwamen de stalker en de manager in actie. / Na de voorstelling bleek dat ze op

meer belangstelling konden rekenen dan hen lief was.) *De stalker achtervolgde de danseres (//) en de manager opende vlug de deur van de gereedstaande limousine.* Toen de danseres in de limousine sprong was ze verlost van de opdringerige fan. Met een noodgang verdween de limousine in de nacht.

20.
Het kostte veel moeite om de drugsbende op te rollen. (Toen ze de koerier op het bureau gekregen hadden, gingen de politieman en de infiltrant verder met het onderzoek. / Toen de undercoveroperatie een succes leek te worden, werd de spanning in het team steeds groter.) *De politieman ondervroeg de koerier (//) en de infiltrant achterhaalde later de naam van de opdrachtgever.* Met die informatie kon de drugsbende worden opgerold. In de week daarna werd de geslaagde operatie uitgebreid besproken in alle actualiteitenprogramma's.

21.
Na een lange, vermoeiende reis verlangde het adellijke gezelschap naar huis. (Toen ze de koetsier al klaar zagen staan, wilden de gravin en de lakei meteen vertrekken. / Toen uiteindelijk het vervoer geregeld was, verliet iedereen de herberg.) *De gravin wenkte de koetsier (//) en de lakei droeg zuchtend de koffers naar de gereedstaande koets.* Een kwartier later reed de koets in hoog tempo weg. Het was nog ruim een dag rijden vanaf de herberg.

22.
Het zangduo was jaren geleden met ruzie uit elkaar gegaan, maar nu in de talkshow zou het misschien toch allemaal goed komen. (Toen ze de zanger overgehaald hadden om toch nog een keer te zingen, waren de presentator en de zangeres ontroerd. / Toen de show bijna afgelopen was, kwam de emotionele climax.) *De presentator omarmde de zanger (//) en de zangeres zong huilend de beginregels van hun eerste hit.* Op het moment dat de zanger inviel begon de hele zaal te klappen. Tegen het einde van het lied grepen veel mensen naar hun zakdoek.

23.
Er was een ernstig auto-ongeluk gebeurd op de A2 tussen Amersfoort en Apeldoorn. (Toen ze de arts zagen aankomen, waren de hulpverlener en de brandweerman opgelucht. / Toen het bericht binnen was gekomen op de centrale meldkamer, was de hulpverlening snel op gang gekomen.) *De hulpverlener informeerde de arts (//) en de brandweerman bevrijdde gehaast het slachtoffer uit de brandende auto.* Nadat alle rommel van de weg was verwijderd, werd de weg weer vrijgegeven. Gelukkig vielen er deze keer geen doden te betreuren.

24.
Kwade draken waren het koninkrijk binnengedrongen en vielen de hoofdstad aan. (Toen ze de koningin de ernst van de situatie uiteen hoorden zetten, wisten de tovenaar en de prinses wat hen te doen stond. / Toen bekend werd dat het paleis in gevaar was, werd besloten machtige magie in te zetten.) *De tovenaar bewaakte de koningin (//) en de prinses haalde gauw het toverboek uit de magische bibliotheek.* Gelukkig konden de draken verslagen worden, zodat het koninkrijk voorlopig weer veilig was. Het was altijd maar weer afwachten hoe lang de nieuw verworven rust zou duren.

25.

Door de gladheid gebeurde er een ernstig auto ongeluk op de smalle binnenweg. (Omdat ze het kind snel uit de auto wilden hebben, begonnen de reddingswerker en de vrouw aan het portier te wrikken. / Toen de hulpdiensten gearriveerd waren, bleek dat de portieren van de auto vast zaten.) *De reddingswerker bevrijdde het kind (//) en de vrouw klom aangeslagen uit de auto.* De ambulance was snel ter plaatse om de gewonden naar het ziekenhuis te brengen.

26.

Omdat het in het bos erg droog was, was het tijdens het scoutingkamp verboden om een kampvuur te maken. (Toen ze de padvinder een vuurtje zagen stoken, snelden de boswachter en de hopman allebei naar de open plek. / Toen bleek dat er toch een vuurtje gemaakt was, duurde het niet lang voor Staatsbosbeheer ingreep.) *De boswachter berispte de padvinder (//) en de hopman doofde gauw het vuurtje met wat scheppen zand.* Zelfs op open plekken was een kampvuur levensgevaarlijk.

27.

De toeristenbus stopte midden op de kade van een oud Grieks stadje, ergens aan de Middellandse Zee. (Toen zij de visser in het schilderachtige haventje zagen staan, liepen de toerist en de reisleider er opgetogen op af. / Toen de vissersboot binnenvoer in het schilderachtige haventje was dat een schitterende gelegenheid om foto's te maken.) *De toerist fotografeerde de visser (//) en de reisleider vertelde gedreven een verhaal over de visserij in de streek.* Het werd een heerlijke dag.

28.

Het café in de achterbuurt was in korte tijd erg trendy geworden. (Terwijl zij de zwerver langs het terras zagen slenteren, kregen de dichter en de dronkaard inspiratie voor een lied. / Op het terras zaten ook gisteren veel verschillende soorten mensen.) *De dichter bezong de zwerver (//) en de dronkaard prees luidkeels de schoonheid van de Amsterdamse grachten.* Zelfs na middernacht was het nog druk op het terras.

29.

Het prestigieuze bouwproject op het universiteitsterrein was zo goed als afgerond. (Toen zij de aannemer op grove fouten bij de bouw hadden betrapt, reageerden de professor en de architect geïrriteerd. / Toen er vlak voor de oplevering van de collegezaal een flinke lekkage werd geconstateerd, moest er snel iets gebeuren.) *De professor belde de aannemer (//) en de architect eiste direct een onderzoek door een onafhankelijk bureau.* De aannemer weigerde elke verantwoordelijkheid voor de fouten op zich te nemen.

30.

Toen de trui uit de uitverkoop werd teruggebracht, ontstond er een discussie over het ruilen. (Nadat ze de bedrijfsleider om toestemming gevraagd hadden, wisten de klant en de verkoper dat de trui geruild mocht worden. / Hoewel kledingstukken uit de uitverkoop niet geruild mochten worden, werd er in de boetiek wel eens

een uitzondering gemaakt.) *De klant bedankte de bedrijfsleider (//) en de verkoper vroeg meteen de kassabon om de trui te ruilen.* De bedrijfsleider nam met een hoffelijk gebaar afscheid.

31.
In groep acht van de St. Eustachius school kampte een kind met ernstige leerproblemen. (Omdat ze de leerling wilden helpen, hadden de lerares en de moeder een afspraak gemaakt. / Omdat de school wat meer wilde weten over de mogelijke oorzaak hiervan, was er voor die avond een afspraak gemaakt.) *De lerares begroette de leerling (//) en de moeder beschreef uitvoerig de thuissituatie van het lastige kind.* Besloten werd om een 'remedial teacher' in te schakelen om te proberen de problemen op te lossen.

32.
De rederij had de bemanning van de Batavia verplicht naar de kerk te gaan, vlak voordat het schip uit zou varen. (Toen ze de stuurman ziek rond zagen lopen, sloegen de pastoor en de kapitein een kruis. / Toen het schip toestemming kreeg om te vertrekken, werd de mis snel afgehandeld.) *De pastoor zegende de stuurman (//) en de kapitein bedankte zuchtend de geestelijke voor zijn goede zorgen.* De bootreis verliep verder voorspoedig.

33.
Net als bij de vorige reizen van de edelman was er ook dit keer enorm veel bagage. (Toen zij de baron van het vliegveld ophaalden, wisten de chauffeur en de butler precies wat er moest gebeuren. / Het vervoer naar het landgoed was geen enkel probleem, aangezien er voldoende bedienden waren.) *De chauffeur vervoerde de baron (//) en de butler bracht keurig de bagage naar het kasteel.* Iedereen was blij de baron weer terug te zien na zijn lange reis.

34.
Er zou vandaag in de filmstudio een gevaarlijke en moeilijke stunt opgenomen worden voor de nieuwe James Bond film. (Toen ze de stuntman alweer zagen falen in zijn stunt, waren de acteur en de producent ontzettend boos. / De stunt was al twee keer eerder mislukt, en mislukte nu een derde keer.) *De acteur vervloekte de stuntman (//) en de producent gooide woedend zijn dikke sigaar op de grond.* Uiteindelijk werd de stunt, die te moeilijk bleek te zijn, vervangen door een achtervolgingsscène.

35.
Op het gemeentehuis van Beek kwam die middag een voorstel aan de orde voor het verbeteren van het gemeentelijke basisonderwijs. (Toen zij de leraar de vergaderruimte binnen zagen komen, waren de burgemeester en de onderzoeker zo enthousiast dat zij de vergadering meteen begonnen. / Het plan was samen met de universiteit en de basisschool ontwikkeld.) *De burgemeester ondervroeg de leraar (//) en de onderzoeker onderkende zakelijk de voordelen van het nieuwe onderwijsplan.* De leden van de raad wisten dat ze met dit nieuwe plan veel waardering zouden krijgen van de inwoners.

36.

Na het debat in de Kamer werden de hoofdpersonen nog eens aan de tand gevoeld in een interview. (Nadat ze de interviewer de laatste vraag hadden horen stellen, konden het Kamerlid en de minister vrijuit spreken. / Toen het gesprek was afgelopen, heerste er een lacherige, wat cynische stemming bij de aanwezigen.) *Het Kamerlid bespotte de interviewer (//) en de minister herhaalde minachtend de vragen die hem gesteld waren.* Het vraaggesprek, oorspronkelijk bedoeld voor het NOS-journaal, werd wijselijk niet uitgezonden.

37.

Al weken voor het staatsbezoek werd er een uitgebreid veiligheidsplan opgesteld, waarbij het leger en de politie samenwerkten. (Toen ze de president aangevallen zagen worden, kwamen de lijfwacht en de generaal geschrokken in actie. / Toen tijdens de parade een bom explodeerde, ontstond er een vreselijke chaos in de stad.) *De lijfwacht beschermde de president (//) en de generaal beval direct zijn troepen de omgeving te doorzoeken.* De president bleef opmerkelijk kalm onder het tumult.

38.

Net tegen sluitingstijd was het opeens heel druk in de binnenstad. (Toen zij de voetganger plotseling zagen oversteken, konden de automobilist en de fietser niet meer op tijd remmen. / Toen de verkeerslichten op het drukke kruispunt plotseling uitvielen, ontstond er een levensgevaarlijke situatie.) *De automobilist raakte de voetganger (//) en de fietser verloor geschrokken zijn evenwicht waardoor hij op straat viel.* De voetganger en de fietser hadden gelukkig alleen maar schaafwonden; de automobilist kwam met de schrik vrij.

39.

Op het landgoed Beerenveldt werd het personeel erg losbandig toen de familie het landhuis voor een paar dagen had verlaten. (Toen zij het dienstmeisje in de tuin zagen lopen, werden de tuinman en de butler erg nieuwsgierig. / De afwas stapelde zich op in de keuken, en zelfs de tuinpaden werden niet van bladeren ontdaan.) *De tuinman bespiedde het dienstmeisje (//) en de butler pakte meteen een verrekijker om haar te bekijken.* Toen de familie weer terugkwam, deed iedereen alsof er niets gebeurd was.

40.

Circus Grimaldi stond bekend om zijn chaotische slotacts. (Toen zij de goochelaar woest op hen af zagen komen, maakten de clown en de acrobaat dat ze wegkwamen. / Toen het laatste onderdeel werd uitgevoerd, duurde het niet lang of het hele circus was in rep en roer.) *De clown ontvluchtte de goochelaar (//) en de acrobaat beklom de ladder naar de nok van de tent.* Elke avond was die laatste act weer een groot succes.

41.

Tijdens de excursie van de afdeling kunstgeschiedenis was het iedereen duidelijk dat het verboden was om foto's te maken. (Toen zij de student toch zagen fotograferen, liepen de suppoost en de studente er meteen heen. / Toen bleek dat er toch werd gefotografeerd, werd er meteen ingegrepen.) *De suppoost waarschuwde de student (//) en de studente stopte snel de camera in haar tas.* De jongen en het meisje waren toch erg blij dat ze een foto hadden van hun favoriete schilderij.

42.
In de Zonneheuvel-kliniek was een zwaar psychiatrisch geval opgenomen. (Toen ze de patiënt binnen gebracht zagen worden, waren de psychiater en de assistent zeer alert. / Omdat in het verleden vaak verkeerde diagnoses werden gesteld, werd er nu volgens nieuwe richtlijnen gewerkt.) *De psychiater observeerde de patiënt (//) en de assistent noteerde zorgvuldig de medische gegevens in het dossier.*
Na een half uur werd de man naar de afdeling gebracht.

43.
In het dorp waar iedereen elkaar kende was de wekelijkse groentemarkt altijd een gezellig gebeuren. (Toen ze de kennis aan zagen komen lopen, stopten de huisvrouw en het kind voor een praatje. / De mensen kwamen er net zozeer voor een gezellig praatje als voor de boodschappen.) *De huisvrouw zoende de kennis (//) en het kind bekeek nieuwsgierig de mensen die langs hen heen liepen.* Het kind werd echter al snel vervelend en zeurde om een ijsje.

44.
Het was verre van duidelijk hoe het schoonmaakmiddel in de partij babyvoeding van Olvarit terecht had kunnen komen. (Toen ze de werknemer erover ondervroegen, kregen de directeur en de chef de feitelijke toedracht te horen. / Na een diepgaand onderzoek in het producerend bedrijf kwam de ware toedracht aan het licht.) *De directeur ontsloeg de werknemer (//) en de chef riskeerde vervolgens zijn baan door hiertegen te protesteren.*
Inmiddels waren de meeste potjes babyvoeding teruggehaald uit de winkels.

45.
Bij de gemeente was bezwaar aangetekend tegen de uitbreiding van een verffabriek. (Toen ze de wethouder het bezwaarschrift af hoorden wijzen, waren de burgemeester en de ondernemer het daar van harte mee eens. / Toen het bezwaarschrift werd afgewezen, kon de uitbreiding gewoon doorgaan.) *De burgemeester loofde de wethouder (//) en de ondernemer liet meteen een fles dure cognac bezorgen.* De milieuorganisatie, die het bezwaarschrift had ingediend, liet het daar echter niet bij zitten.

46.
Allengs werd duidelijk dat de honden zo geblaft hadden omdat iemand het koninklijk paleis was binnengedrongen. (Terwijl ze de lakei de dief zagen verjagen keken de koningin en de hofdame geschrokken toe. / Toen bleek dat de dief uiteindelijk verjaagd was, keerde de rust weer in het paleis.) *De koningin beloonde de lakei (//) en de hofdame kreeg meteen een rode kleur van opwinding.* Later bleek dat de dief een aantal van de mooiste sieraden had gestolen.

47.
Met veel geslinger kwam het vliegtuig uiteindelijk tot stilstand op het grasveld naast de landingsbaan. (Hoewel ze de piloot zijn excuses hoorden maken, waren de reiziger en de stewardess nog steeds boos. / Toen het vliegtuig eenmaal stilstond, heerste er een angstige stemming.) *De reiziger vervloekte de piloot (//) en de*

stewardess opende haastig de nooduitgangen van het vliegtuig. De passagiers werden met een busje naar de hal van het vliegveld gebracht.

48.
In de tuin van de familie van Dorp gebeurde vanmiddag een ongeluk met een cirkelzaag. (Toen ze de man naar de operatiekamer brachten, waren de chirurg en de vrouw ongerust. / In het ziekenhuis bleek dat er meteen geopereerd moest worden wilde de afgezaagde vinger gered kunnen worden.) *De chirurg troostte de man (//) en de vrouw legde bezorgd haar hand op zijn warme voorhoofd.* Binnen een kwartier was de man klaar voor de operatie.

49.
De raket voor de nieuwe maanexpeditie stond gereed. (Terwijl ze de technicus naar de raket zagen lopen, waren de astronaut en de monteur de laatste controles door aan het spreken. / Terwijl de laatste controles uitgevoerd werden, heerste er een gespannen sfeer in het controlecentrum in Houston.) *De astronaut groette de technicus (//) en de monteur opende behoedzaam de sluis van de gereedstaande raket.* Toen de astronaut op zijn plek zat kon het aftellen beginnen. De lancering van de raket verliep zonder problemen.

50.
De legendarische rockband gaf een optreden om hun nieuwe cd te promoten. (Terwijl ze de drummer een heel oud nummer hoorden aankondigen begonnen de fan en de gitarist te schelden. / Omdat iedereen op het podium was geklommen, was het daar nogal chaotisch.) *De fan belaagde de drummer (//) en de gitarist riep ontzet de beveiliging die al paraat stond.* Ondanks dat ging het concert gewoon door. Het was een geweldig optreden geworden.

51.
Op het politiebureau was ruzie toen een omvangrijke fraude met parkeerbonnen aan het licht was gekomen. (Toen ze de parkeerwacht zich hoorden verdedigen, stonden de commissaris en de rechercheur geërgerd op. / Er was onenigheid over wie schuldig was aan de fraude.) *De commissaris bedreigde de parkeerwacht (//) en de rechercheur vertrok woedend waarbij hij de deur dicht smeet.* Uiteindelijk bleek dat de parkeerwacht onschuldig was, de rechercheur was dus terecht kwaad geworden.

52.
Op de opgravingslocatie in Mexico heerste een vrolijke stemming. (Terwijl ze de indiaan tot de grote geest hoorden bidden, bekeken de archeoloog en de graver een oud artefact dat ze zojuist hadden gevonden. / Er was namelijk een belangrijk en zeldzaam artefact gevonden in de oude nederzetting.) *De archeoloog betaalde de indiaan (//) en de graver stopte netjes alle spullen in een grote koffer.* De opgravinglocatie werd altijd zo netjes mogelijk achter gelaten. ’s Avonds zou er een feestelijke presentatie zijn in het museum.

53.

De kunstbijlage van de krant stond bekend om zijn felle kritieken. (Toen ze de criticus binnen zagen komen schoten de dichter en de redacteur overeind. / Nadat een nieuwe dichtbundel onterecht de grond in was geboord, kreeg de krant onverwacht bezoek.) *De dichter belaagde de criticus (//) en de redacteur besloot meteen een uitvoerige rectificatie te plaatsen.* Zo was het misverstand snel de wereld uitgeholpen. De dichter zou echter voorgoed een hekel hebben aan de krant.

54.

Er was een luizenplaag geconstateerd in het opvangcentrum voor dak- en thuislozen. (Toen ze de junk hoorden schreeuwen wisten de verpleger en de zwerfster dat dit een hele klus ging worden. / Iedereen die langs kwam bij het centrum werd grondig gewassen om de luizen te verdrijven.) *De verpleger verschoonde de junk (//) en de zwerfster waste mopperend zijn gezicht met water en zeep.* Er kwam nog heel wat geworstel aan te pas om de junk te wassen. Ondanks het gebruikelijke gemopper gingen alle bezoekers weer schoon en fris de deur uit.

55.

Het altaar werd na de mis grondig schoongemaakt. (Toen ze de koorknaap de kelk om zagen stoten, schrokken de kapelaan en het hulpje zich een ongeluk. / De serene rust werd plotseling verstoord door het lawaai van een kelk die werd omgestoten.) *De kapelaan vermaande de koorknaap (//) en het hulpje wist nauwelijks zijn lachen te bedwingen.* Het hele altaarkleed zat onder de wijn en moest zeker gestoomd worden.

56.

In het kleine Afrikaanse dorp hadden kwade geesten bezit genomen van een jager. (Omdat ze de bezetene een gevaar voor zichzelf vonden, besloten de medicijnman en het opperhoofd dat ze rigoureuze maatregelen moesten nemen. / Een magisch beschermend elixer werd ijlings klaargemaakt.) *De medicijnman besprenkelde de bezetene (//) en het opperhoofd goot voorzichtig olie over het vreemde masker.* Toen de rituelen voltooid waren, hadden de geesten de bezetene voorgoed verlaten.

57.

Na de slechte oogst van vorig jaar moest de god van de regen weer gunstig gestemd worden. (Toen ze de slavin in trance zagen gaan wisten de priester en de slaaf dat de offerplechtigheid kon beginnen. / Om de veiligheid van iedereen te waarborgen moest er een ritueel met een mensenoffer volbracht worden.) *De priester offerde de slavin (//) en de slaaf bewierookte dromerig het stenen beeld van de godheid.* Zo waren de stamleden verzekerd van een goede oogst.

58.

In het oosterse tempelcomplex was het die morgen mogelijk om de gebedsruimte te bezoeken. (Toen ze de goeroe het vertrek binnen zagen komen, bogen de bezoeker en de ingewijde respectvol hun hoofd. / Vanwege de hevige sneeuwval had maar één iemand het gewaagd de steile berg naar het klooster te beklimmen.) *De bezoeker vereerde de goeroe (//) en de ingewijde luisterde ademloos naar zijn gepassioneerde toespraak.* Voor de bezoeker ging een levenslange wens in vervulling.

59.
Ondanks de veiligheidsmaatregelen werd de vergadering van de G8 toch nog verstoord. (Toen ze de lijfwacht opeens zagen telefoneren werden de activist en de officier zenuwachtig. / De anti-globalistische beweging was er weer eens in geslaagd om iemand het gebouw binnen te smokkelen.) *De activist besmeurde de lijfwacht (//) en de officier morste geschrokken koffie op zijn smetteloze uniform.* Na een kleine worsteling kon de activist ingerekend worden.

60.
Op de oosterse bazaar waren veel typisch Arabische voorstellingen te zien. (Omdat ze de toeschouwer geld uit zijn zakken wilden kloppen, deden de fakir en de danseres hun optreden extra fanatiek. / De artiesten voerden vol enthousiasme hun voorstellingen op, in de hoop zoveel mogelijk te verdienen.) *De fakir betoverde de toeschouwer (//) en de danseres vertoonde geamuseerd haar sensuele buikdans.* Er hing altijd een gezellige sfeer op de bazaar.

NP-Coordinations

1.
Modehuis Antje had de bruidskleding verzorgd van de trouwerij die nu in het gemeentehuis plaatsvond. (Toen ze de prachtige jurk van de bruid gezien hadden, waren de schoonvader en de bruidegom helemaal onder de indruk. / De prachtige kleding paste perfect bij de feestelijke gelegenheid.) *De schoonvader feliciteerde de bruid (//) en de bruidegom in het middeleeuwse stadhuis met hun feestelijke bruiloft.* Snel werden er nog wat foto's gemaakt van het ontroerende tafereel. Het werd nog een mooie dag.

2.
Het was de bedoeling dat het kraakpand aan de Keizersgracht die dag zou worden ontruimd. (Toen ze de kraker uit het pand zagen komen, liepen de journalist en de agent er meteen op af. / Zowel de sterke arm van de wet als de pers waren in grote getale aanwezig.) *De journalist interviewde de kraker (//) en de agent op de rumoerige Dam waar hevige rellen bezig waren.* De kraker liet zich gewillig meevoeren naar de politiebus. Na een paar uur was het hele pand ontruimd.

3.
Het alarm ging heel hard af in de winkel. (Toen ze de bewaker aan zagen komen lopen, werden de klant en de verkoper steeds bozer. / Hierdoor ontstond een verwarring die een agressief tintje had.) *De klant beledigde de bewaker (//) en de verkoper in een hoogoplopende ruzie om een beschuldiging van diefstal.* Uiteindelijk bleek dat het alarm uit zichzelf was afgegaan. De verkoper bood de boze klant zijn excuses aan.

4.
Het schoolgebouw brandde als een fakkel, met name de noodgebouwen, die helemaal van hout waren. (Toen ze de conciërge vanuit de gymzaal hoorden roepen, waren de brandweerman en de leraar nog steeds in de hal. /

Toen bekend werd dat er nog mensen in de school waren, verzamelde de brandweercommandant zijn dapperste mannen.) *De brandweerman redde de conciërge (//) en de leraar uit de brandende school voordat deze instortte*. Gelukkig vielen er geen slachtoffers te betreuren. De brand was vrijwel zeker aangestoken.

5.

Op het feest in het café van het kleine mijnwerkersdorpje was gedurende de avond erg veel gedronken. (Toen zij de notaris in zijn jas wilden helpen, merkten de dokter en de pastoor dat het café leegliep. / Zelfs de notabelen van het dorpje hadden van het feest genoten.) *De dokter ondersteunde de notaris (//) en de pastoor naar de verlichte uitgang van het café op de markt.* De burgers die het tafereel gadesloegen, schudden hun hoofd. Maar nog steeds met respect.

6

Die woensdagmiddag waren er veel kinderen met hun ouders in de stad. (Toen ze de baby hoorden huilen keken de moeder en het meisje geschrokken op. / Een aantal voorbijgangers keek verstoord op toen ze een luid gekrijs hoorden.) *De moeder troostte de baby (//) en het meisje met een lekker ijsje met aardbeiensmaak.* Toen de ijsjes op waren gingen ze snel richting auto, omdat de kinderen alweer ongedurig werden. Gelukkig hadden ze toch nog nieuwe zomerkleren kunnen kopen.

7.

Het ziekenhuis stond goed bekend als het ging om hartoperaties. (Hoewel ze de patiënt nauwkeurig hadden onderzocht, hadden de chirurg en de specialist nog niet het juiste behandeltraject vastgesteld. / In de bespreking voor de operatie was er een discussie gaande over het uit te voeren behandeltraject.) *De chirurg overtuigde de patiënt (//) en de specialist in een lang gesprek over de noodzaak van een operatie.* Uiteindelijk werd de patiënt geopereerd. Verwacht werd dat hij binnen een maand volledig hersteld zou zijn.

8.

Het was vijf voor zes in de avond en nog steeds was er geen bier afgeleverd. (Toen ze de leverancier van het bier het straatje in zagen komen, waren de stamgast en de kroegbaas dan ook zeer verheugd. / Er was nog maar één stamgast overgebleven in het café, toen het bier uiteindelijk kwam.) *De stamgast loofde de leverancier (//) en de kroegbaas met een theatraal gebaar en een uitbundig lied*. Lachend werden de eerste pilsjes weer getapt. Deze waren uiteraard op het huis.

9.

De nieuwe werkplaats van Schelling's IJzerwaren was nu definitief klaar. (Toen ze de timmerman binnen zagen komen, praatten de winkelier en de metselaar lovend over het afgeleverde werk. / Omdat er veel stenen en hout in de aanbouw waren gaan zitten, werd er nog stevig onderhandeld over de prijs.) *De winkelier betaalde de timmerman (//) en de metselaar voor de nieuwe aanbouw die zij voor hem gebouwd hadden*. Hij gaf toch ook een niet onaanzienlijke fooi, terwijl Schelling als een zuinig iemand bekend stond.
De werkplaats was dan ook erg mooi afgewerkt.

10.

De reddingsactie voor de schone dames uit de hofhouding, die door de draak ontvoerd waren, was in volle gang. (Toen ze de jonkvrouw in het duister gewaar werden, waren de ridder en de dienares erg opgelucht. / Het was duidelijk dat de actie zo snel mogelijk uitgevoerd moest worden.) *De ridder bevrijdde de jonkvrouw (//) en de dienares uit het donkere hol van de gevaarlijke draak.* Groot was de vreugde in het kasteel toen bleek dat de jonkvrouw weer terug was. Maar groot ook was de angst dat het weer zou gebeuren.

11.

Op donderdagavond werd er een groot feest gehouden ter ere van de verjaardag van het bedrijf. (Toen ze de stagiair naar het feestje meenamen, waren de boekhouder en de telefoniste heel vrolijk. / Zelfs de gehele administratieve afdeling was op komen dagen.) *De boekhouder complimenteerde de stagiair (//) en de telefoniste op het gezellige feestje omdat zij mooi gekleed waren.* Het feest werd gehouden in een zaaltje vlakbij het bedrijf. Iedereen had de dag erna maar vrijgenomen om uit te kunnen slapen.

12.

De president van Chili bracht een bezoek aan Nederland. (Toen ze de president van het vliegveld ophaalden, waren de ambassadeur en de tolk gespannen. / Dit was een belangrijke diplomatieke gebeurtenis omdat er gewichtige economische verdragen opgesteld moesten worden.) *De ambassadeur begroette de president (//) en de tolk op het drukke vliegveld waar zij opgewacht werden.* Het bezoek verliep zonder incidenten.

13.

Bij de indianenstam in het binnenland van Zuid-Amerika bestond veel vertrouwen in de oude geneeswijzen. (Toen ze de medicijnman bij zijn tent ontmoetten, gingen de zieke en het stamhoofd rustig zitten. / Zij hadden veel kennis van de geneeskrachtige planten uit het bos.) *De zieke raadpleegde de medicijnman (//) en het stamhoofd in het kleine dorp aan de rand van het bos.* Zij gaven hem een kruidenmengsel dat zijn pijn moest verzachten. Een aantal dagen na het bezoek ging de zieke al weer jagen.

14.

Bij de islamitische nomadenstam uit Soedan werd een jonge vrouw uitgehuwelijkt. (Toen ze de imam zijn oordeel hoorden geven, waren het meisje en het dorpsoudste stil. / Dit is voor de betrokkenen niet altijd even prettig, maar er is moeilijk tegenin te gaan.) *Het meisje gehoorzaamde de imam (//) en de dorpsoudste in het eenzijdige besluit dat zij met haar neef moest trouwen.* Haar toekomstige man zat in eenzelfde situatie. Ze hadden wel een schitterend huwelijksfeest.

15.

In het paleis heerste een vrolijke stemming vanwege de recente overwinning van het koninklijke leger op het vijandige buurland. (Omdat ze de koning wilden verrassen, hadden de hofnar en de maarschalk een feest georganiseerd. / Tijdens het feest ter ere van de overwinning waren de gehele hofhouding en de koninklijke familie aanwezig.) *De hofnar feliciteerde de koning (//) en de maarschalk in de grote troonzaal met de*

overwinning. Het feest begon met een spontane toespraak van de koning, maar barstte al snel los. Uitbundig werd de overwinning gevierd.

16.
Tijdens de voetbalwedstrijd ging het er af en toe heftig aan toe. (Toen ze de keeper een grove overtreding zagen maken, liepen de scheidsrechter en de aanvoerder naar de penaltystip. / Na een grove overtreding ontstond er een hevige woordenwisseling op het veld.) *De scheidsrechter bestrafte de keeper (//) en de aanvoerder met een gele kaart vanwege hun brutale gedrag.* De aanvoerder was stiekem blij dat zijn team er zo gemakkelijk van af was gekomen. Uiteindelijk verloren ze toch nog met 3-0.

17.
Voor het slapen gaan mochten de kinderen nog een voorleesverhaaltje kiezen. (Toen ze het jongetje slaperig zagen worden, sloegen de oppas en het meisje het voorleesboek dicht. / Na het voorlezen waren de kinderen erg moe, en werden naar bed gebracht.) *De oppas zoende het jongetje (//) en het meisje op hun warme hoofdjes en stopte ze in bed.* Ze had het wel getroffen, vond ze, met dit oppasadres. Sommige kinderen kreeg ze met geen mogelijkheid naar bed.

18.
In de laatste aflevering van de quiz kon de absolute hoofdprijs vergeven worden. (Toen ze de deelnemer de laatste vraag goed hoorde beantwoorden, begonnen de quizmaster en de assistente te juichen. / De kandidaat deed zijn uiterste best om de grootste prijs in zijn bezit te krijgen.) *De quizmaster omhelsde de deelnemer (//) en de assistente voor de draaiende camera's omdat de prijs eruit ging.* Toen de prijs, een fonkelnieuwe Volkswagen Golf, werd voorgereden was de deelnemer uitzinnig van vreugde. Triomfantelijk stapte hij in zijn nieuwe auto.

19.
Die dag werd er in Brussel een bijzondere tentoonstelling geopend van twee zeer verschillende kunstenaars. (Toen ze de schilder uitgezwaaid hadden, liepen de directeur en de beeldhouwer nog even door het museum. / Op de receptie waren zowel het bestuur van het museum als de twee kunstenaars aanwezig.) *De directeur bewonderde de schilder (//) en de beeldhouwer in het mooie museum in het zuiden van de stad.* Het was een unicum dat de kunstenaars buiten Frankrijk exposeerden. De directeur was erg trots op de tentoonstelling.

20.
In het studentenhuis waar twee kamers werden verhuurd heerste al langere tijd een nare sfeer. (Toen ze de hospita voor de derde keer confronteerden met achterstallig onderhoud, waren de student en de huisgenoot laaiend. / Omdat er kamernood in de stad was, was de eerstejaars toch maar in de kamer blijven zitten.) *De student haatte de hospita (//) en de huisgenoot in een hoogopgelopen geschil over het akelige huis.* Jammer genoeg was er niet zo snel een andere kamer voorhanden. Zo snel als hij een kamer zou vinden, zou hij hier weg zijn.

21.

Van de “Black Feather ranch” waren binnen een uur vijftien paarden gestolen. (Toen ze op zoek waren naar de indiaan, waren de sheriff en de cowboy elkaar kwijtgeraakt. / Omdat er sporen waren gevonden werd het gebergte ten oosten van de ranch doorzocht.) *De sheriff zag de indiaan (//) en de cowboy achter een grote rotspunt die scherp tegen de lucht afstak.* Het bleek dat de indiaan de paarden had gestolen. Gelukkig waren de paarden nu weer terecht.

22.

De dansles werd deze keer in een ander gebouw gegeven. (Toen ze de beheerder hadden gevonden, vroegen de dansleraar en de cursist welk lokaal voor hun gereserveerd was. / Omdat niemand de weg wist naar het lokaal werd er iemand gezocht die dit wel wist.) *De dansleraar volgde de beheerder (//) en de cursist in het nieuwe gebouw waar hij de weg niet kende.* Het lokaal bleek niet moeilijk te vinden. Ook de pianist was al aanwezig.

23.

Omdat een vrouw haar echtgenoot verdacht van een buitenechtelijke relatie op het werk, schakelde ze een detectivebureau in. (Terwijl ze de directeur ’s avonds aan hoorden komen rijden, waren de detective en de secretaresse tot het uiterste gespannen. / Toen hij voor de zoveelste keer zei dat hij moest overwerken, tipte ze het bureau.) *De detective fotografeerde de directeur (//) en de secretaresse in het donkere bedrijfspand om hun relatie aan te tonen.* De foto’s lieten niets aan duidelijkheid te wensen over. Na het zien van deze foto’s wilde de vrouw niets meer met haar man te maken hebben.

24.

Een oudere vrouw was op straat vanaf een brommer bestolen. (Toen ze de bijrijder van de brommer zagen vallen, renden de getuige en de bestuurder naar hem toe. / Een omstander zag het gebeuren en dwong de brommer te stoppen.) *De getuige sloeg de bijrijder (//) en de bestuurder in een woeste opwelling om hun respectloos gedrag.* De twee dieven maakten zich geschrokken uit de voeten. Gelukkig konden zij later door de politie opgepakt worden, zodat zij hun straf niet ontkwamen.

25.

De gemeente wilde proberen om de bewoners van de boerderij uit te kopen. (Toen ze de boer resoluut hoorden weigeren, wisten de ambtenaar en de boerin dat het moeilijk zou worden. / Een nieuwe snelweg was precies over het erf van de oude boerderij gepland.) *De ambtenaar overtuigde de boer (//) en de boerin met een goed bod tijdens een lang gesprek*. Uiteindelijk verkochten de boer en de boerin hun boerderij voor veel geld.

26.

In het kleine ziekenhuis in Boxtel hing nog steeds een gemoedelijke sfeer. (Toen ze de patiënt in de gang zagen lopen waren de dokter en de verpleegster verheugd. / Men nam nog de tijd voor een persoonlijk gesprek.) *De dokter begroette de patiënt (//) en de verpleegster met een vriendelijke glimlach omdat hij goede zin had.* Opgetogen begon hij een praatje over het mooie weer.

27.

De balkonscène met de lange monoloog bleek lastig te filmen. (Terwijl ze de actrice overstuur zagen zitten, spraken de regisseur en de cameraman nog eens het script door. / Toen de opname voor de zoveelste keer opnieuw moest, ontstond er een bijzonder emotionele sfeer.) *De regisseur kalmeerde de actrice (//) en de cameraman op de koude set zodat er opnieuw gefilmd kon worden*. De actrice was bijna in tranen, maar ze ging door tot de regisseur tevreden was.

28.

Ter gelegenheid van het 25 jarig jubileum van de uitgeverij werd er aan een speciale uitgave gewerkt. (Toen ze de schrijver zijn stuk hoorden presenteren waren de uitgever en de dichter erg verheugd over het resultaat. / Het moest een boek worden met een gewaagde combinatie van proza en poëzie.) *De uitgever bedankte de schrijver (//) en de dichter voor het prachtige boek dat ze samen hadden geschreven.* Iedereen was erg trots op het eindresultaat.

29.

Tijdens een nachtelijke rondleiding in het bos vond de scouting een paar vossenklemmen. (Toen ze de stroper weg zagen vluchten zetten de padvinder en de boswachter de achtervolging in. / Omdat het duidelijk was dat ze er nog maar net lagen, werd het bos van voor tot achter doorzocht.) *De padvinder zag de stroper (//) en de boswachter tijdens een woeste worsteling over de grond rollen*. De stroper kreeg een behoorlijke boete.

30.

Het politiebureau in de achterstandswijk kreeg een waardevolle tip over een omvangrijke fraudezaak. (Toen ze de buurman op het politiebureau binnen zagen komen, wisten de fraudeur en de beambte dat het spel uit was. / Tijdens het onderzoek liepen de gemoederen erg hoog op.) *De fraudeur sloeg de buurman (//) en de beambte op het lokale politiebureau uit woede over het verraad*. De fraudeur werd een nacht in de cel gezet om wat af te koelen.

31.

Op de basisschool werden zowel de post als de schoolmelk altijd rond het middaguur gebracht. (Terwijl ze de postbode de school in zagen komen, waren de conciërge en de melkboer erg vrolijk. / Vandaag was de middagpauze nog niet begonnen, dus was het nog rustig in de school.) *De conciërge riep de postbode (//) en de melkboer vanuit de lege kantine om hen koffie aan te bieden*. De school was verreweg het gezelligste adres van de hele ronde.

32.

Er stond die dag in het Vaticaan een belangrijk kerkelijk overleg op het programma. (Omdat ze de kardinaal zeer waardeerden waren de paus en de bisschop erg tevreden met zijn komst. / Een klein aantal hoogwaardigheidsbeklederswas voor een lunch uitgenodigd.) *De paus verwelkomde de kardinaal (//) en de bisschop in de mooie privévertrekken van zijn paleis*. Ze waren helemaal uit Afrika gekomen om de paus op de hoogte te brengen van wat daar speelde.

33.

Voor het starten van het bedrijf was veel geld nodig. (Omdat ze de geldschieter een goed ondernemingsplan hadden gestuurd waren de ondernemer en de notaris optimistisch. / Om de benodigde lening te krijgen, werd er een goed ondernemingsplan bij de bank voorgelegd.) *De ondernemer bezocht de geldschieter (//) en de notaris in een opgewekte stemming, omdat de vooruitzichten goed waren*. Toen zijn plan werd goedgekeurd kon de ondernemer zijn bedrijf op gaan zetten.

34.

Toen de lente vroeg inzette, kwamen op het Waterlooplein het toerisme en het straatleven weer langzaam op gang. (Terwijl ze de straatmuzikant vals hoorden spelen stonden de toerist en de marktkoopman geamuseerd te kijken. / Hoewel het nog erg koud was, was er al een aantal mensen op de markt.) *De toerist fotografeerde de straatmuzikant (//) en de marktkoopman op het koude plein dat er zo schilderachtig uitzag*. Foto's van mensen vond hij altijd mooier dan die van landschappen of gebouwen.

35.

Vanavond was er in het Concertgebouw een concert uit de serie Moderne Stukken. (Terwijl ze de percussionist in hoorden spelen, bespraken de componist en de violist nog eens de partituur. / Net voor de uitvoering werd het stuk nog een keer doorgesproken.) *De componist instrueerde de percussionist (//) en de violist in de grote repetitieruimte opdat de uitvoering perfect zou gaan.* Hoewel de componist zelf niet helemaal tevreden was, bleek het publiek erg onder de indruk.

36.

Na het Tweede-Kamerdebat over de varkenspest werd er gedemonstreerd door een eenzame vertegenwoordiger van Lekker Dier. (Nadat ze de minister de plannen hadden horen uitleggen waren de demonstrant en de ambtenaar diep teleurgesteld. / Nadat de plannen bekend gemaakt werden, bleken die totaal ontoereikend.) *De demonstrant bekogelde de minister (//) en de ambtenaar bij de grote poort naar het Binnenhof.* Luid protesterend werd de demonstrant meegevoerd door twee agenten.

37.

Het was ideaal weer voor een wandeling door de imposante tuinen van het kasteel. (Toen ze de vorst aan zagen komen, stonden de troubadour en de maîtresse op van het bankje waarop ze zaten. / Een deel van de hofhouding was vandaag dan ook in de tuinen te vinden.) *De troubadour bezong de vorst (//) en de maîtresse in de prachtige rozentuin waar zij zich hadden teruggetrokken*. Het was algemeen bekend dat de koning er meerdere vrouwen op nahield.

38.

Het klusbedrijf lapte alle milieuregels aan zijn laars. (Terwijl ze de schilder zijn advocaat hoorden bellen controleerden de milieuwachter en de loodgieter de werkplaats. / Toen iemand de milieudienst daarvan op de

hoogte stelde, werd er direct actie ondernomen.) *De milieuwachter bekeurde de schilder (//) en de loodgieter voor het illegaal dumpen van de verf.* Ze kregen een aanzienlijke boete.

39.
Sinds de jaren zestig was er op het eiland een dictatuur gevestigd. (Omdat ze de generaal verdachten van ontrouw, bedachten de dictator en de adjudant een manier om van hem af te komen. / Toen het veertigjarig jubileum van het bewind werd gevierd, werden ook de eerste tekenen van een op handen zijnde machtsstrijd zichtbaar.) *De dictator wantrouwde de generaal (//) en de adjudant in het lange omdat hij paranoïde was.* Vermoedelijk waren ze niet tevreden met hun huidige aandeel in de macht.

40.
De reis ging door een moeilijk toegankelijk gedeelte van het Andesgebergte. (Doordat ze de drager voorop lieten lopen, hadden de reiziger en de gids de grootste moeite om bij te blijven. / Toen de schemering inviel, moest er nog een flink stuk gelopen worden langs een gapend ravijn.) *De reiziger volgde de drager (//) en de gids door het bergachtige gebied waar ze doorheen moesten.* Hij was ontzettend opgelucht toen ze een vlakker stuk bereikten waar ze de tenten konden opzetten.

41.
De makelaar zorgde altijd voor een goed contact tussen zijn cliënten. (Omdat ze de koper al vaker hadden gesproken, waren de makelaar en de verkoper optimistisch over het succesvol afronden van de zaak. / Toen de koop vanwege de aantrekkelijke prijs door leek te gaan, was dat natuurlijk een enorm succes.) *De makelaar ontving de koper (//) en de verkoper op zijn luxe kantoor om het voorlopige koopcontract te tekenen.* Hij vond het leuk om hier een gezellige sfeer omheen te creëren.

42.
Tijdens de vergadering werd uitgebreid over het begrotingstekort gesproken. (Toen ze de voorzitter de financiële situatie hoorden beschrijven schoten de secretaris en de penningmeester geërgerd overeind. / Toen de discussie daarover net was begonnen, werd er al geprotesteerd.) *De secretaris onderbrak de voorzitter (//) en de penningmeester in de verhitte vergadering omdat hij vond dat er een rekenfout in de begroting zat.* Uiteindelijk bleek dat de secretaris gelijk had en dat het tekort niet zo groot was.

43.
Op de ziekenhuiszaal lag een oudere heer, die zich niet aan het rookverbod wenste te houden. (Toen ze de arts erg boos zagen worden keken de bejaarde en de verzorgster elkaar geschrokken aan. / Hoewel het streng verboden was om te roken, vond men een halfopgerookte sigaar naast zijn bed.) *De bejaarde beschimpte de arts (//) en de verzorgster in het schone verpleeghuis omdat hij meende dat zij hem kinderachtig behandelden.* Mopperend hees hij zich overeind om in het gastenvertrek een sigaartje te gaan roken.

44.
De oude stoomtrein was door een vereniging van treinliefhebbers weer nieuw leven ingeblazen. (Terwijl ze de conducteur op zijn fluitje hoorden blazen keken de kleuter en de machinist geboeid naar de trein. / Toen de trein voor het eerst in jaren weer zou rijden, waren er veel mensen gekomen om dat te zien.) *De kleuter bewonderde de conducteur (//) en de machinist bij de oude trein vanwege hun mooie uniformen.* Hij stond met open mond naar de glimmende locomotief te kijken die grote wolken stoom uitblies.

45.
De officier van justitie stelde een aanzienlijke vermindering van celstraf in het vooruitzicht, in ruil voor het afleggen van een belastende verklaring. (Toen ze de medeplichtige zijn onschuld hoorden bepleiten, keken de crimineel en de opdrachtgever elkaar veelbetekenend aan. / Omdat het een goede deal leek, werd er welwillend op ingegaan.) *De crimineel verlinkte de medeplichtige (//) en de opdrachtgever tijdens het intensieve verhoor op het politiebureau*. Dankzij zijn getuigenis konden de kopstukken van de drugsbende achter slot en grendel gezet worden.

46.
Toen bij het laden van de boot de vracht voor de tweede keer viel, ging men eindelijk beter opletten. (Omdat ze de stuurman nogal onhandig vonden, waren de schipper en de bootwerker erg gespannen. / Heel voorzichtig werd de lading in het ruim getakeld.) *De schipper vervloekte de stuurman (//) en de bootwerker in een agressieve reactie toen de lading opnieuw viel.* Na veel vloeken en tieren was de boot eindelijk geladen.

47.
Het museum had net voor veel geld een prachtig schilderij gekocht op de kunstveiling. (Toen ze de curator belden over de presentatie, spraken de veilingmeester en de antiquair af om alle drie aanwezig te zijn. / De presentatie van het schilderij was een groots gebeuren.) *De veilingmeester ontmoette de curator (//) en de antiquair in het mooie museum bij de onthulling van het schilderij*. Iedereen was erg te spreken over het mooie nieuwe doek.

48.
Vanwege de staking heerste er een grimmige stemming rond de mijn. (Toen ze de vakbondsman het laatste nieuws hadden horen geven, werden de staker en de mijnwerker nog bozer. / Er ontstond een gevecht tussen de voorman van hen die het werk weer hervat hadden, en de voorman van hen die bleven staken.) *De staker bekogelde de vakbondsman (//) en de mijnwerker bij de oude mijn omdat hij zich bedrogen voelde*. Een deel van de mijnwerkers ging na de onderhandelingen weer aan het werk, terwijl een ander deel bleef staken.

49.
De garage stond bekend als erg goedkoop, maar het wilde ook nogal eens voorkomen dat er slordig werd gewerkt. (Terwijl ze de monteur van onder de motorkap vandaan zagen komen stonden de automobilist en de garagehouder te praten. / Toen de auto de garage uitgereden werd, zat er een grote kras op de motorkap.) *De automobilist beschuldigde de monteur (//) en de garagehouder in de smerige garage van het beschadigen van*

zijn autolak. De automobilist hield vol dat de garagehouder moest betalen. De garagehouder bleef dit weigeren, en de automobilist schakelde de consumentenbond in.

50.
De kopman van de wielerploeg was in het bergklassement van de Tour de France als eerste geëindigd. (Toen ze de verzorger aan zagen komen lopen zwaaiden de wielrenner en de coach enthousiast. / Dat was een enorme prestatie voor de nieuwe wielerploeg.) *De wielrenner riep de verzorger (//) en de coach op het versierde podium omdat hen veel eer toekwam.* Na de prijsuitreiking werden ze overspoeld door journalisten. Iedereen was benieuwd wat ze volgend jaar zouden presteren.

51.
Toen er een nieuw dieptepunt voorspeld werd, hing er een grimmige stemming op de beurs. (Toen ze de obligatiehouder aan de telefoon hadden bespraken de econoom en de speculant verhit de huidige situatie. / Iedereen was bezig de risico's zo veel mogelijk te spreiden.) *De econoom waarschuwde de obligatiehouder (//) en de speculant in het lange gesprek over de naderende recessie.* Zowel de obligatiehouder als de speculant verkochten een groot deel van hun portefeuille. Twee weken later was de koers echter weer gestabiliseerd.

52.
Toen het handelsschip door piraten geënterd werd, kwam het tot een bloedig man-tot-man-gevecht. (Terwijl ze de stuurman zijn sabel zagen trekken, schreeuwden de kapitein en de piraat luid. / Sabelgekletter was over het hele dek te horen.) *De kapitein zag de stuurman (//) en de piraat op het gladde dek gespannen vechten voor hun leven*. Uiteindelijk werden de piraten van de boot verdreven. Het schip voer snel naar de haven waar het veilig was voor verdere aanvallen.

53.
De plaatsing van de keuken liep niet geheel volgens de planning die het bedrijf had doorgegeven. (Toen ze de tegelzetter hoorden klagen over de te kleine ruimte, vreesden de aannemer en de installateur dat het plan omgegooid moest worden. / Het bleek dat er fouten waren gemaakt bij het opnemen van de maten.) *De aannemer riep de tegelzetter (//) en de installateur op een geërgerde toon toen duidelijk werd dat de keuken niet paste*. Na het inkorten van het aanrecht en het verplaatsen van de koelkast paste de keuken precies.

54.
De boksfinale had een ongewoon einde. (Hoewel ze de scheidsrechter het eindsignaal zagen geven, bleven de titelverdediger en de uitdager toch doormeppen. / Na een vuile overtreding werd de partij stilgelegd.) *De titelverdediger sloeg de scheidsrechter (//) en de uitdager in een enorme uitbarsting van woede*. Als straf mocht de titelverdediger 3 jaar niet meer boksen. Dit zou betekenen dat hij een hoop geld mis zou lopen.

55.
De blessure van de nieuwe ster van het schaatsteam was net voor het begin van het schaatsseizoen genezen. (Terwijl ze de haptonoom het goede nieuws hoorden vertellen, waren de schaatser en de masseur erg blij. / Dit

was erg goed nieuws, aangezien de eerste wedstrijd van het schaatsseizoen al over twee weken was.) *De schaatser bedankte de haptonoom (//) en de masseur in het geavanceerde sportcentrum waar ze een bespreking hadden*. In de openingswedstrijd van het seizoen behaalde de schaatser met ruime voorsprong de eerste plaats.

56.
Na de dood van de oude koning was de relatie tussen de provincies ernstig verslechterd. (Terwijl ze de prins nauwlettend in de gaten hielden, versterkten de hertog en de ridder hun strijdkrachten. / Er waren grote onenigheden over de landsverdeling in het rijk.) *De hertog bevocht de prins (//) en de ridder in een hoogopgelopen geschil over een aantal belangrijke landgoederen*. Uiteindelijk trouwde de prins met een dochter van de hertog en werd het conflict zonder bloedvergieten opgelost.

57.
Op de school was een discussie ontstaan over de schorsing van een leerling. (Omdat ze de rector onredelijk vonden wilden de moeder en de mentor eens precies weten hoe de situatie lag. / Zoals altijd zaten er aan het verhaal twee kanten.) *De moeder schreef de rector (//) en de mentor over de onterechte schorsing van haar zoon*. Uiteindelijk mocht de leerling weer op school komen.

58.
De normaal zo rustige kerk werd nu verstoord door het geluid van een Gameboy. (Omdat ze de dominee aan hoorden komen werden het rotjoch en de koster wat rustiger. / Toen het speelgoed werd afgepakt begon het kind te gillen.) *Het rotjoch schopte de dominee (//) en de koster in de kleine kerk omdat zij hem brutaal noemden*. De dominee belde direct de ouders van het vervelende kind om hem op te komen halen.

59.
Omdat het jachtseizoen nog niet was begonnen en er toch schoten gehoord werden ging de beheerder van het landgoed op onderzoek uit. (Toen ze de drijver geschrokken achter de struik vandaan zagen komen keken de opziener en de jager elkaar kwaad aan. / Het duurde niet lang voordat hij de overtreders had gevonden.) *De opziener berispte de jager (//) en de drijver in het grote bos waar ze konijnen geschoten hadden.* Ze moesten niet alleen hun konijnen inleveren, maar kregen ook nog eens een fikse boete.

60.
De trein kon nog niet vertrekken aangezien de bestuurder er nog niet was. (Toen ze de machinist aan zagen komen rennen keken de conducteur en de stationschef opgelucht. / Nadat hij was omgeroepen kwam hij vlug het perron oprennen.) *De conducteur begroette de machinist (//) en de stationschef op het drukke perron waarvan de trein moest vertrekken*. Het bleek dat de machinist zich had vergist, en alvast pauze was gaan nemen.

References

Abrams, K., & Bever, T. G. (1969). Syntactic structure modifies attention during speech perception and recognition. *The Quarterly Journal of Experimental Psychology*, *21*, 280 – 290.

Altmann, G., & Steedman, M. (1988). Interaction with context during human sentence processing. *Cognition*, *30*, 191 – 238.

Andersen, J. E., & Holcomb, P. J. (2005). An electrophysiological investigation of the effects of coreference on word repetition and synonymy. *Brain and Language*, *94*, 200 – 216.

Astésano, C., Besson, M., & Alter, K. (2004). Brain potentials during semantic and prosodic processing in French. *Cognitive Brain Research*, *18*, 172 – 184.

Baayen, H., Piepenbrock, R., & Van Rijn, H. (1993). The CELEX lexical database [CD-ROM]. Linguistic Data Consortium. Philadelphia, PA: University of Pennsylvania.

Balcony, M., & Pozzoli, U. (2005). Comprehending semantic and grammatical violations in Italian. N400 and P600 comparison with visual and auditory stimuli. *Journal of Psycholinguistic Research, 34*, 71 – 98.

Besson, M., & Kutas, M. (1993). The many facets of repetition: A cued recall and event-related potential analysis of repeating words in same versus different sentence contexts. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*, 1115 – 1133.

Bever, T. G. (1970). The cognitive basis for linguistic structures. In J. R. Hayes (Ed.), *Cognition and the development of language* (pp. 279–352). New York: Wiley.

Bögels, S., Schriefers, H., Vonk, W., Chwilla, D. J., and Kerkhofs, R. (in press). The Interplay between Prosody and Syntax in Sentence Processing: The Case of Subject- and Object-Control Verbs. *Journal of Cognitive Neuroscience*.

Cabeza, R., & Nyberg, L. (2000). Imaging cognition II: An empirical review of 275 PET and fMRI studies. *Journal of Cognitive Neuroscience*, *12*, 1-4.

Chomsky, N. (1980). *Rules and representations*. New York: Columbia University Press.

Christophe, A., Peperkamp, S., Pallier, C., Block, E., & Mehler, J. (2004). Phonological phrase boundaries constrain lexical access. I. Adult data. *Journal of Memory and Language*, *51*, 523 – 547.

Chwilla, D. J. (1996). The lexical processing nature of the N400 priming effect. Unpublished doctoral dissertation, University of Nijmegen, the Netherlands.

Chwilla, D. J., Brown, C. M., & Hagoort, P. (1995). The N400 as a function of the level of processing. *Psychophysiology*, *32*, 274 – 285.

Chwilla, D. J., Hagoort, P., & Brown, C. M. (1998). The mechanism underlying backward priming in lexical decision: Spreading activation versus semantic matching. *Quarterly Journal of Experimental Psychology*, *51*, 531–560.

Collier, R., & ‘t Hart, J. (1975). The role of intonation in speech perception. In A. Cohen & S. G. Nooteboom (Eds.), *Structure and process in speech perception* (pp. 107 – 121). Heidelberg: Springer-Verlag.

Coulson, S., King, J. W., & Kutas, M. (1998). ERPs and domain specificity: Beating a straw horse. *Language and Cognitive Processes*, *13*, 653 – 672.

Christophe, A., Gout, A., Peperkamp, S., & Morgan, J. (2003). Discovering words in a continuous speech stream: The role of prosody. *Journal of Phonetics*, *31*, 585 – 598.

Christophe, A., Peperkamp, S., Pallier, C., Block, E., & Mehler, J. (2004). Phonological phrase boundaries constrain lexical access. I. Adult data. *Journal of Memory and Language*, *51*, 523 – 547.

Cutler, A., Dahan, D., & Van Donselaar, W. (1997). Prosody in the comprehension of spoken language: A literature review. *Language and Speech*, *40*, 141-201.
De Pijper, J. R., & Sanderman, A. A. (1994). On the perceptual strength of prosodic boundaries and its relation to suprasegmental cues. *Journal of the Acoustical Society of America*, *96*, 2037 – 2047.
Eckstein, K., & Friederici, A. D. (2005). Late interaction of syntactic and prosodic processes in sentence comprehension as revealed by ERPs. *Cognitive Brain Research*, *25*, 130 – 143.
Epstein, W. (1961). The influence of syntactical structure on learning. *American Journal of Psychology*, *74*, 80 – 85.
Fodor, J. A. (1983). *The modularity of mind: An essay on faculty psychology*. Cambridge, MA: Harvard University Press.
Fodor, J. D. (2002). Prosodic disambiguation in silent reading. In M. Hirotani (Ed.), *Proceedings of NELS 32* (pp. 113-132). Amherst, MA: GLSA.
Frazier, L. (1987). Syntactic processing: Evidence from Dutch. *Natural Language and Linguistic Theory*, *5*, 519 – 559.
Frazier, L., & Clifton, C., Jr. (1996). *Construal*. Cambridge, MA: MIT Press.
Frazier, L., & Clifton, C., Jr. (1997). Construal: Overview, motivation, and some new evidence. *Journal of Psycholinguistic Research*, *26*, 277 – 295.
Friederici, A. D. (1995). The time course of syntactic activation during language processing: A model based on neuropsychological and neurophysiological data. *Brain and Language*, *50*, 259 – 281.
Friederici, A. D. (2002). Towards a neural basis of auditory sentence processing. *Trends in Cognitive Science*, *6*, 78 – 84.
Friederici, A. D., Hahne, A., & Mecklinger, A. (1996). Temporal structure of syntactic parsing: Early and late event-related brain potentials. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 1219 – 1248.
Friederici, A. D., Hahne, A., & Saddy, D. (2002). Distinct neurophysiological patterns reflecting aspects of syntactic complexity and syntactic repair. *Journal of Psycholinguistic Research*, *31*, 45 – 63.
Friederici, A. D., Pfeifer, E., & Hahne, A. (1993). Event-related brain potentials during natural speech processing: Effects of semantic, morphological and syntactic violations. *Cognitive Brain Research*, *1*, 183 – 192.
Friederici, A. D., Steinhauer, K., & Frisch, S. (1999). Lexical integration: Sequential effects of syntactic and semantic information. *Memory & Cognition*, *27*, 438 – 453.
Friederici, A. D., Steinhauer, K., Mecklinger, A., & Meyer, M. (1998). Working memory constraints on syntactic ambiguity resolution as revealed by electrical brain responses. *Biological Psychology*, *47*, 193 – 221.
Geers, A. E. (1978). Intonation contour and syntactic structure as predictors of apparent segmentation. *Journal of the Acoustical Society of America*, *4*, 273 – 283.
Geerts, G., Haeseryn, W. W., De Rooij, J., & Van den Toorn, M. C. (1984). *Algemene Nederlandse Spraakkunst [General grammar and usage of Dutch]*. Groningen: Wolters-Noordhof.
Gernsbacher, M. A., & Jescheniak, J. D. (1995). Cataphoric devices in spoken discourse. *Cognitive Psychology*, *29*, 24 – 58.
Givón, T. (1983). Topic continuity in discourse: A quantitive cross-language study. In T. Givón (Ed.), *Topic continuity in discourse: An introduction* (pp. 1 – 42). Amsterdam: Benjamins.

Grosz, B., & Hirschberg, J. (1992). Some intonational characteristics of discourse structure. *Proceedings of the Second International Conference on Spoken Language Processing* (pp. 429 – 432). Banff, Canada.

Grosz, B., Hirschberg, J., & Nakatani, C. H. (1994). A study of intonation and discourse structure in directions. *Working papers of the Workshop on the Integration of Natural Language and Speech Processing, American Association for Artificial Intelligence*, 121 - 131.

Gussenhoven, C. (2004). Transcription of Dutch intonation. In S. Jun (Ed.), *Prosodic typology and transcription: A unified approach* (pp. 118 – 145). Oxford: Oxford University Press.

Hagoort, P., & Brown C. M. (2000). ERP effects of listening to speech: Semantic ERP effects. *Neuropsychologia*, *38*, 1518 – 1530.

Hagoort, P., & Brown C. M. (2000). ERP effects of listening to speech compared to reading: The P600/SPS to syntactic violations in spoken sentences and rapid serial visual presentation. *Neuropsychologia*, *38*, 1531 – 1549.

Hagoort, P., Brown, C. M., & Osterhout, L. (1999). The neurocognition of syntactic processing. In C. M. Brown & P. Hagoort (Eds.), *The neurocognition of language* (pp. 273-316). Oxford: Oxford University Press.

Hahne, A. & Friederici, A. D. (1999). Electrophysiological evidence for two steps in syntactic processing: Early autonomic and late controlled processes. *Journal of Cognitive Neuroscience, 11*, 194 – 205.

Hahne, A., & Friederici, A. D. (2002). Differential task effects on semantic and syntactic processes as revealed by ERPs. *Cognitive Brain Research*, *13*, 339 – 356.

Hoeks, J. C. J., Hendriks, P., Vonk, W., Brown, C. M., & Hagoort, P. (2005). Processing the noun phrase versus subject coordination ambiguity: Thematic information does not completely eliminate processing difficulty. *Quarterly Journal of Experimental Psychology*, *59*, 1581 – 1599.

Hoeks, J. C. J., Vonk, W., & Schriefers, H. (2002). Processing coordinated structures in context: The effect of topic-structure on ambiguity resolution. *Journal of Memory and Language, 46*, 99 – 119.

Holcomb, P. J. (1993). Semantic priming and stimulus degradation: Implications for the role of the N400 in language processing. *Psychophysiology*, *30*, 47 – 61.

Holcomb, P. J., & Neville, H. J. (1991). The electrophysiology of spoken sentence processing. *Psychobiology*, *19*, 286 – 300.

Ischebeck, A. K., Friederici, A. D., & Alter, K. (2008). Processing prosodic boundaries in natural and hummed speech: An fMRI study. *Cerebral Cortex*, *18*, 541 - 552.

Isel, F., Gunter, T.C., & Friederici, A. D. (2003). Prosody-assisted head-driven access to spoken German compounds. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*, 277 – 288.

Isel, F., Alter, K., & Friederici, A. D. (2005). Influence of prosodic information on the processing of split particles: ERP evidence from spoken German. *Journal of Cognitive Neuroscience*, *17*, 154 – 167.

Kaan, E., & Swaab, T. Y. (2003). Repair, revision, and complexity in syntactic analysis: An electrophysiological differentiation. *Journal of Cognitive Neuroscience*, *15*, 98 – 100.

Kerkhofs, R., Vonk, W., Schriefers, H., & Chwilla, D. J. (2007). Discourse, syntax, and prosody: The brain reveals an immediate interaction. *Journal of Cognitive Neuroscience*, *19*, 1421 – 1434.

Kerkhofs, R., Vonk, W., Schriefers, H., & Chwilla, D. J. (2008). Sentence processing in the visual and auditory modality: Do comma and prosodic break have parallel functions? *Brain Research*, *1224*, 102 – 118.

Kim, A., & Osterhout, L. (2005). The independence of combinatory semantic processing: Evidence from event-related potentials. *Journal of Memory and Language, 52*, 205 – 225.

King, J. W., & Kutas, M. (1995). Who did what and when? Using word and clause-level ERPs to monitor working memory usage in reading. *Journal of Cognitive Neuroscience*, *7*, 376 – 395.

Kluender, R., & Kutas, M. (1993). Bridging the gap: Evidence from ERPs on the processing of unbounded dependencies. *Journal of Cognitive Neuroscience*, *5*, 196 – 214.

Knösche, T. R., Neuhaus, C., Haueisen, J., Alter, K., Maess, B., Witte, O. W., & Friederici, A. D. (2005). Perception of phrase structure in music. *Human Brain Mapping*, *24*, 259 – 273.

Koelsch, S., Gunter, T. C., Schröger, E., & Friederici, A. D. (2003). Processing tonal modulations: An ERP study. *Journal of Cognitive Neuroscience*, *15*, 1149 – 1159.

Kuperberg, G. R. (2007). Neural mechanisms of language comprehension: Challenges to syntax. *Brain Research, 1146,* 23 – 49.

Kutas, M., & Van Petten, C. (1994). Psycholinguistics electrified: Event-related brain potential investigations. In M. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 83 – 143). New York: Academic Press.

Kutas, M., & Hillyard, S. A. (1984). Brain potentials reflect word expectancy and semantic association during reading. *Nature*, *307*, 161 – 163.

Kutas, M., & Schmitt, B. M. (2003). Language in μV. In M. T. Banich & M. Mack (Eds.), *Mind, brain, and language: Multidisciplinary perspectives* (pp. 171 – 209). Mahwah: Erlbaum.

Lambrecht, K. (1994). *Information structure and sentence form: Topic, focus, and the mental representation of discourse referents*. Cambridge: Cambridge University Press.

Leonard, L. B. (1974) The role of intonation in the recall of various linguistic stimuli. *Language and Speech*, *16*, 327 – 335.

Li, C. N., & Thompson, S. A. (1976). Subject and topic. In C. N. Li (Ed.), *Subject and topic: A new typology of language* (pp. 457 – 490). New York: Academic Press.

Mak, W. M., Vonk, W., & Schriefers, H. (2002). The influence of animacy on relative clause processing. *Journal of Memory and Language*, *47*, 50 – 68.

Mak, W. M., Vonk, W., & Schriefers, H. (2008). Discourse structure and relative clause processing. *Memory & Cognition*, *36*, 170 – 181.

Mange, C., Astésano, C., Lacheret-Dujour, C., Morel, M., Alter, K., & Besson, M. (2005). Online processing of "pop-out" words in spoken French dialogues. *Journal of Cognitive Neuroscience*, *17*, 740 – 756.

Marslen-Wilson, W. D., Tyler, L. K., Warren, P., Grenier, P., & Lee, C. S. (1992). Prosodic effects in minimal attachment. *The Quarterly Journal of Experimental Psychology*, *45*, 73 – 87.

McKinnon, R., & Osterhout, L. (1996). Constraints on movement phenomena in sentence processing: Evidence from event-related brain potentials. *Language and Cognitive Processes*, *11*, 495 – 523.

Mietz, A., Toepel, U., Ischebeck, A., & Alter, K. (2008). Inadequate and infrequent are not alike: ERPs to deviant prosodic patterns in spoken language comprehension. *Brain and Language*, *104*, 159 – 169.

Münte, T. F., Szentkuti, A., Wieringa, B. M., Matzke, M., & Johannes, S. (1997). Human brain potentials to reading syntactic errors in sentences of different complexity. *Neuroscience Letters*, *235*, 105 – 108.

Nagy, M. E., & Rugg, M. D. (1989). Modulation of event-related potentials by word repetition – The effects of inter-item lag. *Psychophysiology*, *26*, 31-36.

Neville, H., Nicol, J. L., Barss, A., Forster, K. I., & Garrett, M. F. (1991). Syntactically based sentence processing classes: Evidence from event-related brain potentials. *Journal of Cognitive Neuroscience, 3*, 151 – 165.

O'Rourke, T. B., & Holcomb P. J. (2002). Electrophysiological evidence for the efficiency of spoken word processing. *Biological psychology*, *60*, 121 – 150.

Oldfield, R. C. (1971). The assessment and analysis of handedness: Edinburgh inventory. *Neuropsychologia*. *9*, 97 – 113.

Osterhout, L., & Holcomb, P. J. (1992). Event-related brain potentials elicited by syntactic anomaly. *Journal of Memory and Language*, *31*, 785 – 806.

Osterhout, L., & Holcomb, P. J. (1993). Event-related potentials and syntactic anomaly: Evidence of anomaly detection during the perception of continuous speech. *Language and Cognitive Processes, 8*, 413 – 438.

Osterhout, L., Holcomb, P. J., & Swinney, D. A. (1994). Brain potentials elicited by garden-path sentences: Evidence of the application of verb information during parsing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*, 786 – 803.

Osterhout, L., McLaughlin, J., Kim, A., & Inoue, K. (2004). Sentences in the brain: Event-related potentials as real-time reflections of sentence comprehension and language learning. In M. Carreiras & C. Clifton, Jr. (Eds.), *The on-line study of sentence comprehension: Eyetracking, ERP, and beyond* (pp. 271 – 308). East Sussex: Psychology Press.

Pannekamp, A., Toepel, U., Alter, K., Hahne, A., & Friederici, A. D. (2005). Prosody-driven sentence processing: An event-related brain potential study. *Journal of Cognitive Neuroscience, 17*, 407 – 421.

Renkema, J. (2004). *Schrijfwijzer [Guidelines for writing]*. Den Haag: SDU.

Rietveld, A. C. M. (1980). Word boundaries in the French language. *Language and Speech*, *23*, 289 – 296.

Rösler, F., Friederici, A. D., Pötz, P., & Hahne, A. (1993). Event related brain potentials while encountering semantic and syntactic constraint violation. *Journal of Cognitive Neuroscience*, *5*, 345 – 362.

Rösler, F., Pechman, T., Streb, J., Röder, B., & Henninghausen, E. (1998). Parsing of sentences in a language with varying word order: Word-by-word variations of processing demands are revealed by event-related potentials. *Journal of Memory and Language*, *38*, 150 – 176.

Salverda, A. P., Dahan, D., & McQueen, J. M. (2003). The role of prosodic boundaries in the resolution of lexical embedding in speech comprehension. *Cognition*, *90*, 51 – 89.

Sanders, E., & Metselaar, K. (2000). *Stijlboek NRC Handelsblad [Style guide NRC Handelsblad]*. Utrecht: Van Dale Lexicografie.

Schlesewsky, M., & Bornkessel, I. (2006). Context sensitive neural responses to conflict resolution: Electrophysiological evidence from subject-object ambiguities in language comprehension. *Brain Research*, *1098*, 139 - 157.

Schriefers, H., Friederici, A. D., & Kühn, K. (1995). The processing of locally ambiguous relative clauses in German. *Journal of Memory and Language*, *34*, 499 - 520.

Shattuck-Hufnagel, S., & Turk, A. E. (1996). A prosody tutorial for investigators of auditory sentence processing. *Journal of Psycholinguistic Research*, *25*, 193 – 247.

Steinhauer, K. (2003). Electrophysiological correlates of prosody and punctuation. *Brain and Language*, *86*, 142 – 164.

Steinhauer, K., Alter, K., & Friederici, A. D. (1999). Brain potentials indicate immediate use of prosodic cues in natural speech processing. *Nature Neuroscience*, *2*, 191 – 196.

Steinhauer, K., & Friederici, A. D. (2001). Prosodic boundaries, comma rules, and brain responses: The closure positive shift in ERPs as a universal marker for prosodic phrasing in listeners and readers. *Journal of Psycholinguistic Research*, *30*, 267 – 295.
Toepel, U., Pannekamp, A., & Alter, K. (2007). Catching the news: Processing strategies in listening to dialogs as measured by ERPs. *Behavioral and Brain Functions*, *3*, 53 - 66.
Van Berkum, J. J. A., Brown, C. M., & Hagoort, P. (1999). Early referential context effects in sentence processing: Evidence from event-related potentials. *Journal of Memory and Language*, *41*, 147 – 182.
Van Berkum, J. J. A., Hagoort, P., & Brown, C. M. (1999). Semantic integration in sentences and discourse: Evidence from the N400. *Journal of Cognitive Neuroscience*, *11*, 657 – 671.
Van Berkum, J. J. A., Zwitserlood, P., Hagoort, P., & Brown, C. M. (2003). When and how do listeners relate a sentence to the wider discourse? Evidence from the N400 effect. *Cognitive Brain Research*, *17*, 701 – 718.
Van den Brink, D., Brown, C. M., & Hagoort, P. (2001). Electrophysiological evidence for contextual influences during spoken-word recognition: N200 versus N400 effects. *Journal of Cognitive Neuroscience, 13,* 967 – 985.
Van Herten, M., Kolk, H. H. J., & Chwilla, D. J. (2005). An ERP study of P600 effects elicited by semantic anomalies. *Cognitive Brain Research*, *22*, 241 – 255.
Van Petten, C., & Bloom, P. (1999). Speech boundaries, syntax and the brain. *Nature Neuroscience*, *2*, 103 – 104.
Van Petten, C., Coulson, S., Rubin, S., Plate, E., & Parks, M. (1998). Time course of word identification and semantic integration in spoken language. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25,* 394 – 417.
Vasey, M. W., & Thayer, J. F. (1987). The continuing problem of false positives in repeated measures ANOVA in psychophysiology: A multivariate solution. *Psychophysiology, 24*, 479 – 486.
Vos, S. H., Gunter, T. C., Kolk, H. H. J., & Mulder, G. (2001). Working memory constraints on syntactic processing: An electrophysiological investigation. *Psychophysiology*, *38*, 41 – 63.
Watt, S. M., & Murray, W. S. (1996). Prosodic form and parsing commitments. *Journal of Psycholinguistic Research*, *25*, 291 - 318.
Wingfield, A., & Klein, J. F. (1971). Syntactic structure and acoustic pattern in speech perception. *Perception & Psychophysics*, *9*, 23 – 25.
Woodward, S. H., Owens, J., & Thompson, L. W. (1990). Word-to-word variation in ERP component latencies: spoken words. *Brain and Language*, *38*, 488 – 503.

Summary

The main question addressed in the present thesis was whether prosodic information and syntactic information interact immediately when they become available. We addressed this question by using sentences that were locally ambiguous. In locally ambiguous sentences, an ambiguity arises and is resolved within the same sentence. Take for example sentence (1), which contains a coordination ambiguity. In this example *and the farm hand* is ambiguous: It is either an elaboration of the NP *the farmer* that is the object of *protected* (called NP-coordination), or it is the onset of a new clause (where it will be the subject of a new verb; called S-coordination). The ambiguity in this sentence is resolved as an S-coordination when the disambiguating verb *defended* is encountered.

(1) The sheriff protected the farmer and the farm hand defended bravely the ranch against Johnson's gang.

In Dutch, a sentence like (1) can also be disambiguated before the onset of the lexically disambiguating verb by means of a comma between *farmer* and *and* as in (1').

(1') The sheriff protected the farmer, and the farm hand defended bravely the ranch against Johnson's gang.

Reading studies have shown that ambiguous sentences like (1) are more difficult to process than unambiguous sentences like (1') (e.g., see Hoeks, Vonk, & Schriefers, 2002, and Hoeks et al., 2005). This is reflected by longer reading times on the lexically disambiguating verb *defended* for ambiguous sentences compared to unambiguous sentences. That is, in ambiguous sentences, the NP *and the farm hand* is initially interpreted as an elaboration of the NP *the farmer*. When encountering the lexically disambiguating verb *defended*, it becomes clear that *and the farm hand* was the onset of a new clause, and thus that a syntactic break was present following *the farmer*. The repair of the original analysis leads to longer reading times on *defended*. By contrast, in (1'), the comma following *the farmer* already signals the onset of a new clause following *the farmer*, and thus the presence of a syntactic break at this location. The syntactic information of interest in the present thesis was the presence versus absence of a syntactic break following *the farmer*.

In this thesis we studied sentence processing in the auditory modality, and more specifically, the interaction between syntactic information and prosodic information. We started out by assuming that a prosodic break is the auditory equivalent of a comma in (1'). A prosodic break is characterized by a pitch rise on the last syllable of *the farmer*, followed by a pause between *the farmer* and *and*. The pitch-rise on the last syllable may be combined with a lengthening of this syllable. A prosodic break is typically the way a comma is "pronounced". The prosodic information of interest was the presence or absence of a prosodic break following *the farmer*.

If the interaction between prosodic information and syntactic information takes place immediately when the two types information become available, it should take place at the location of the prosodic break (following *the farmer* in Sentence (1)). However, this leaves us with a problem: The presence of a syntactic break only becomes apparent at the lexically disambiguating verb *defended*. In fact, it appears to be impossible to study the immediate interaction between syntactic information and prosodic information using locally ambiguous sentences in isolation.

We provided a solution to this problem by embedding the sentences in contexts which either induce the expectation of a syntactic break following *the farmer*, or which do not induce such an expectation. To induce the expectation of a syntactic break at the position of

the prosodic break, we made use of two principles of topic structure. The first principle is the principle of minimal topic structure. This principle holds that in the absence of any other cues or additional information, the simplest topic structure (the topic-comment structure) is the preferred topic structure. In other words, by default readers and listeners assume one topic per sentence. Note that S-coordination sentences violate this principle: in (1) both *the sheriff* and *the farm hand* are topic. The second principle is topic continuity (Givón, 1983). If a discourse entity has fulfilled the role of topic earlier in a discourse, then there is a preference for having that same entity take the role of topic in a new sentence. That is, readers and listeners have a preference for coherent discourses that are about the same topic.

To induce the expectation of an S-coordination, sentences like (1) were embedded in a discourse context (see Table 1). In the critical context sentence (B.2 in Table 1) the first NP (*the sheriff*) and the third NP (*the farm hand*) were introduced as topics. When listeners hear *The sheriff*, they assume this NP to fulfill the role of topic, following the principle of topic continuity. However, given the structure of the biasing context sentence, *the farm hand* wants to be topic as well. Furthermore, there is a strong tendency to have topics fulfill the syntactic function of subject of the sentence (Li & Thompson, 1976). Therefore, the listener will assume a syntactic structure of the target sentence (C in Table 1) in which it is possible that the farm hand is a topic (and thus to be in the subject position). The obvious way to accomplish this is to assume that after *the farmer* a new clause will start with *the farm hand* as the subject. This leads to the expectation of a syntactic break following *farmer*. This context was called the S-coordination biasing context, or biasing context for short. The biasing context was contrasted with a neutral context, which provided a general setting in which the target sentence would fit (see B.1 in Table 1), but mentioned none of the NPs of the target sentences. Hoeks, Vonk, and Schriefers (2002) have demonstrated that the biasing contexts do indeed induce the expectation of a syntactic break following *the farmer*.

Table 1 Example of an experimental item used in Experiments 1 and 2, with English Translation in italics

A Lead-in sentence
Nog geen dag nadat James “Mad Dog” Johnson werd vrijgelaten uit de gevangenis was het alweer raak in Painful Gulch.
Hardly a day since James "Mad Dog" Johnson's release from prison, trouble started again in Painful Gulch.
B.1 Neutral context
Toen Johnson zijn mannen weer opgetrommeld had, was de grootste boerderij in de buurt het doelwit van hun actie.
After Johnson summoned his men, the largest ranch in the neighborhood was targeted for their raid..
B.2 Biasing context
Toen ze de boer om hulp hoorden roepen, snelden de sheriff en de knecht naar de boerderij.
When they heard the farmer cry for help, the sheriff and the farm hand rushed to the ranch.
C Target sentence
De sheriff beschermde de boer en de knecht verdedigde dapper de boerderij tegen Johnson’s bende.
The sheriff protected the farmer and the farm hand defended bravely the ranch against Johnson's gang.
D Exit sentence 1
Na een vuurgevecht van meer dan drie uur kwam er eindelijk versterking voor de sheriff.
After a firefight of over an hour reinforcements for the sheriff finally arrived.
E Exit sentence 2
Gelukkig kon Johnson nog dezelfde dag weer worden opgesloten.
Luckily Johnson was put behind bars again the very same day.

In Chapter 1, four ERP-components relevant for the present thesis were introduced. The N400, which is mainly associated with semantic processing, the LAN and the P600 which are associated with syntactic processing, and the Closure Positive Shift, the central ERP component of this dissertation, which is elicited by prosodic breaks.

Chapter 2 reported two experiments using coordination sentences in isolation. In Experiment 1, coordination sentences were presented visually. The S-coordination sentences such as (1) were disambiguated by the occurrence of a comma following *the farmer*. The results of Experiment 1 showed no reliable evidence for a comma-induced CPS. The results at

the lexically disambiguating verb of the visually presented sentences (*defended*) were straightforward: The ambiguous sentences, without a comma, showed a biphasic N400-P600 pattern relative to the sentences that were disambiguated by a comma following *the farmer*. These results show that the comma did disambiguate the S-coordination sentences before the onset of the lexically disambiguating verb. This was the case even though the comma did not elicit a CPS.

In Experiment 2 of Chapter 2, the coordination sentences of Experiment 1 were presented in the auditory modality. The S-coordination sentences either had a prosodic break at the location where a comma was present in Experiment 1 or had no prosodic break. The results at the prosodic break showed that the prosodic break elicited a CPS. This confirmed earlier findings in the literature (e.g., Steinhauer, Alter, & Friederici, 1999, and Steinhauer, 2003). The results at the lexically disambiguating verb were different for the first half and second half of the experiment. In the first half, a LAN was found in the sentences without a prosodic break. In the second half of the experiment, a P600 was found in the sentences without a prosodic break. Both results indicate that the prosodic break disambiguates sentences as S-coordination sentences already at the prosodic break.

Chapter 3 investigated the immediate interaction between prosodic information and syntactic information during auditory sentence processing. This chapter reported the results of two experiments in which coordination sentences with and without a prosodic break were embedded in neutral or biasing context conditions. The focus of Chapter 3 was on a potential modulation of the CPS by the contextually induced expectation of a syntactic break at the position of the prosodic break.

In the first experiment the prosodic information (prosodic break present versus prosodic break absent) was always in conflict with the lexical disambiguation of the sentence. That is, sentences with a prosodic break were eventually disambiguated as NP-coordination sentences, and sentences without a prosodic break were eventually disambiguated as S-coordination sentences. In the second experiment, the prosodic information and lexical disambiguation always were in line. The pattern of results was similar for the two experiments. The comparison of the coordination sentences with a prosodic break and without a prosodic break in the Neutral Context condition showed that a CPS was elicited by the prosodic break. The comparison of the identical prosodic break in the Neutral Context condition and the Biasing Context condition showed that the CPS was smaller in amplitude in the Biasing Context condition than in the Neutral Context condition.

In addition, Chapter 3 also reported two sets of supplementary analyses. In the first set, we contrasted the presence versus the absence of a prosodic break in the Biasing Context condition. The results of an overall analysis showed no reliable CPS in the biasing context condition, although one of the individual experiments did show a CPS in the Biasing Context condition. In the second set of analyses, the absence of the prosodic break was analyzed time-locked to the offset of the second NP in the Neutral Context condition, and in the Biasing Context condition. These results suggest that the absence of a prosodic break may be a cue that is used by participants to signal syntactic cohesion.

Chapter 4 reported the data from the two experiments described in Chapter 3 at the syntactically disambiguating elements. To repeat, in Experiment 1 prosodic information and lexical disambiguation were in conflict, whereas in Experiment 2 prosodic information and lexical disambiguation were in line. In Experiment 1, the results at the theoretical uniqueness point of the lexically disambiguating verb of the S-coordination sentences in the Neutral Context condition versus the Biasing Context condition showed an early positive deflection. The results at the onset of the disambiguating PP of the NP-coordinations showed a longer-lasting positive-going deflection for the Biasing Context condition. In both cases, the timing, shape and scalp-distribution did not match any known ERP component. These results were

interpreted to reflect processing difficulty. Processing difficulty occurred in the Neutral Context condition for the S-coordination sentences, and in the Biasing Context condition for the NP-coordination sentences.

In contrast to the results of Experiment 1 (prosodic information and eventual disambiguation in conflict), no differences were found in Experiment 2 (prosodic information and eventual disambiguation in-line) between the waveforms in the Neutral Context condition versus the Biasing Context condition for the lexically disambiguating verbs of the S-coordination sentences. Also for the waveforms at the PPs for the NP-coordination sentences, no differences were obtained between the Neutral Context condition and the Biasing Context condition. From these results we concluded that in Experiment 2 both the S-coordination sentences and the NP-coordination sentences were disambiguated by the prosodic information (i.e., the presence of a prosodic break for S-coordination sentences and the absence of a prosodic break for NP-coordination sentences), such that the contextually induced syntactic expectation had no additional effect.

Appendix I contrasted the use of different alignment points for the auditory ERP-analyses at the lexically disambiguating verb of the S-coordination sentences. In the analyses of the lexically disambiguating verb both in Chapter 2 and in Chapter 4 we used the theoretical uniqueness point of the lexically disambiguating verbs to align the ERP waveforms. In Appendix I we contrasted the effects of using the onset, the offset, and the theoretical uniqueness point of the lexically disambiguating verbs. The results of these analyses showed that the choice of alignment point can have an impact on the ERP-results. The theoretical uniqueness point appeared to be an efficient middle ground between either using the onset or offset of a word for time-locking, or determining the empirical uniqueness point of a word.

To conclude, this dissertation addressed the question whether syntactic information and prosodic information interact immediately when they become available. The results of the experiments show that this is the case: Syntactic information and prosodic information interact immediately after they become available.

Samenvatting

De centrale vraag in dit proefschrift is of prosodische informatie en syntactische informatie elkaar onmiddellijk beïnvloeden zodra zij beschikbaar komen tijdens het verwerken van gesproken tekst. Om dit te onderzoeken hebben we gebruik gemaakt van zinnen met een lokale ambiguïteit. Tijdens het begrijpen van zulke zinnen is er meer dan één interpretatie mogelijk, maar wordt de interpretatie al eenduidig voordat de zin is afgelopen. Een voorbeeld is zin (1) die een coördinatie ambiguïteit bevat. In deze zin is in eerste instantie het deel *en de knecht* ambigu. Immers, wanneer de zin tot en met *de knecht* gelezen wordt is het niet duidelijk of de knecht, net als de boer, beschermd wordt, zoals in zin (2) het geval blijkt, of dat de knecht iets gaat ondernemen, zoals in zin (1) bij *verdedigde* blijkt. In zin (2) maakt *en de knecht* deel uit van *de boer en de knecht* (een zogenaamde NP-coördinatie). In zin (1) is *en de knecht* het begin van een nieuwe deelzin waarin *de knecht* het onderwerp wordt van het tweede deel van de zin (een zogenaamde S-coördinatie). Zin (1) wordt dus door het werkwoord *verdedigde* eenduidig, en daarmee gedisambigueerd.

(1) De sheriff beschermde de boer en de knecht verdedigde dapper de ranch tegen Johnson's bende.
(2) De sheriff beschermde de boer en de knecht voor de schuur waar een hevig gevecht gaande was.

In tekst die gelezen moet worden kan een komma de zin disambigueren voordat het werkwoord *verdedigde* gelezen wordt: In zin (3) duidt de komma aan dat *de knecht* niet bij *de boer* hoort, maar het begin van een nieuwe zin gaat worden.

(3) De sheriff beschermde de boer, en de knecht verdedigde dapper de ranch tegen Johnson's bende.

Eerder leesonderzoek liet zien dat S-coördinatie zinnen (zin (1)) moeilijker te begrijpen zijn dan NP-coördinatie zinnen (zin (2); zie bijvoorbeeld Hoeks, Vonk & Schriefers, 2002, en Hoeks et al., 2005). Het bleek dat het meer tijd kost een woord als *verdedigde* te lezen in een ambigue S-coördinatiezin (zin (1)) dan in een S-coördinatiezin die door een komma wordt gedisambigueerd (zin (3)). Hieruit kon worden afgeleid dat ambigue S-coördinatiezinnen (zin (1)) in eerste instantie geïnterpreteerd worden als een NP-coördinatie (*de boer en de knecht* horen bij elkaar), en dat wanneer de lezer *verdedigde* tegenkomt deze interpretatie moet worden herzien. Met andere woorden, de komma in zin (3) heeft een syntactische grens aangegeven waardoor de lezer direct op het juiste pad wordt gezet. Over deze grenzen gaat het als we het in dit proefschrift hebben over syntactische informatie.

Het onderzoek in dit proefschrift gaat met name over de verwerking van gesproken taal. We hebben voorondersteld dat de prosodische grens (in het Engels: prosodic break) de gesproken variant van de komma is. Een prosodische grens wordt gekarakteriseerd door een pauze op de plaats van de komma in zin (3), voorafgegaan door een verhoging van de toonhoogte en een verlenging van de laatste lettergreep van het woord voor de komma (*de boer*). Dit is intuïtief de manier waarop een komma wordt "uitgesproken".

Als prosodische informatie en syntactische informatie elkaar onmiddellijk zouden beïnvloeden wanneer zij beschikbaar komen, zouden we dat moeten kunnen meten op de plek waar de prosodische grens ligt (op en na *de boer* in (3)). Maar de syntactische grens tussen *de boer* en *en* wordt pas later in de zin duidelijk, bij het werkwoord *verdedigde*, zoals we hebben gezien in zin (1). In feite blijkt het voor zinnen zonder context altijd zo dat informatie over syntactische grenzen pas één of meerdere woorden nadat de grens is opgetreden beschikbaar komt.

In ons onderzoek vonden we een oplossing voor dit probleem door zinnen niet losstaand aan te bieden, maar ingebed in korte verhaaltjes. Deze verhaaltjes roepen een syntactische grens na *de boer* op of doen dat niet. Om deze verhaaltjes te maken hebben we gebruik gemaakt van twee principes van topicstructuur. Het eerste principe is het principe van minimale topic structuur. Dit houdt in dat lezers en luisteraars in eerste instantie uitgaan van de meest simpele topicstructuur. Op voorhand verwachten lezers en luisteraars maar één topic in een zin. Met andere woorden, op voorhand gaan lezers en luisteraars er vanuit dat een zin maar over één ding tegelijkertijd gaat (vandaar de langere leestijden op *verdedigde* in zin (1) ten opzichte van zin (3)). Het tweede principe dat we hebben gebruikt is het principe van topic continuïteit (Givón, 1983). Dit principe houdt in dat wanneer iets of iemand de rol van topic heeft aangenomen in een zin, dat dit iets of deze iemand de rol van topic blijft vervullen, ook in de zin daarna. Met andere woorden, lezers en luisteraars hebben de voorkeur voor samenhangende teksten die over hetzelfde blijven gaan.

Een voorbeeld van een verhaaltje dat een syntactische grens na *de boer* oproept staat in Tabel 1.

Tabel 1. Voorbeeld van het stimulusmateriaal.

A Introductiezin	
	Nog geen dag nadat James “Mad Dog” Johnson werd vrijgelaten uit de gevangenis was het alweer raak in Painful Gulch.
B.1 Neutrale context	
	Toen Johnson zijn mannen weer opgetrommeld had, was de grootste boerderij in de buurt het doelwit van hun actie.
B.2 Experimentele context	
	Toen ze de boer om hulp hoorden roepen, snelden de sheriff en de knecht naar de boerderij.
C Doelzin	
	De sheriff beschermde de boer en de knecht verdedigde dapper de boerderij tegen Johnson’s bende.
D Eindzin 1	
	Na een vuurgevecht van meer dan drie uur kwam er eindelijk versterking voor de sheriff.
E Eindzin 2	
	Gelukkig kon Johnson nog dezelfde dag weer worden opgesloten.

In de experimentele context zin (B.2 in Tabel 1) worden het eerste en derde zelfstandige naamwoord (respectievelijk de *sheriff* en de *knecht*) gepresenteerd als topic. Wanneer luisteraars de doelzin (C in Tabel 1) horen na deze experimentele context leidt het principe van topic continuïteit ertoe dat zowel *de sheriff* als *de knecht* de rol van topic willen vervullen. Voorts is het zo dat topics graag het grammaticale onderwerp van een zin zijn (Li & Thompson, 1976). De luisteraar interpreteert de doelzin door aan te nemen dat *en de knecht* het begin van een nieuwe deelzin is. De doelzin in de experimentele context is vergeleken met dezelfde doelzin in de neutrale context (B.1 in Tabel 1). Deze context beschrijft een algemeen scenario waarbinnen de doelzin past zonder een van de zelfstandige naamwoorden uit de doelzin te noemen. De luisteraar zal in de doelzin in de neutrale context uitgaan van de meest simpele topic structuur en verwachten dat *de knecht* een uitbreiding van *de boer* is. In leesonderzoek vonden Hoeks, Vonk en Schriefers (2002) inderdaad langere leestijden op het werkwoord *verdedigde* wanneer de doelzin vooraf werd gegaan door een neutrale contextzin dan wanneer de doelzin vooraf werd gegaan door een experimentele contextzin. Dit toonde aan dat de experimentele context zin een syntactische grens oproept waardoor de coördinatie gedisambigueerd wordt in een S-coördinatie.

In ons onderzoek maakte we gebruik van dit soort experimentele contexten om een syntactische grens op te roepen op de locatie in de doelzinnen waar aan de luisteraar wel of niet een prosodische grens werd aangeboden. De doelzinnen in de experimentele contexten werden vergeleken met dezelfde doelzinnen in neutrale contexten waarin geen syntactische grens wordt opgeroepen. We hebben gebruik gemaakt van een meettechniek die Event Related Potentials (ERPs) heet. Bij deze techniek wordt van proefpersonen het electroencephalogram (EEG) gemeten terwijl zij naar het stimulusmateriaal van een experiment luisteren. Uit het EEG zijn zogenaamde Event Related Potentials (gebeurtenis-gerelateerde potentialen) te destilleren. Dit zijn karakteristieke reacties van het brein op bepaalde stimuli. De ERPs worden geanalyseerd door de EEG-metingen van een experimentele conditie af te zetten tegen de EEG-metingen van een neutrale controle conditie. Dit wordt gedaan op een bepaalde plek in een zin waar een interessante gebeurtenis (event) op treedt (bijvoorbeeld de aanwezigheid van een komma na *de boer* in zin (3) ten opzichte van de afwezigheid van een komma in zin (1)). Het verschil tussen de experimentele conditie en een controle conditie vormt de feitelijke ERP. Binnen taalonderzoek zijn er een aantal van dit soort ERP-effecten met name relevant. De N400, welke zijn naam ontleent aan het feit dat deze negatief van polariteit is en na 400 ms na een gebeurtenis optreedt, wordt vooral met semantische (betekenis) verwerking geassocieerd. De P600, positieve polariteit na 600 ms, en de LAN, de Left Anterior Negativity, worden met name geassocieerd met syntactische verwerking. Tot slot wordt de CPS, de Closure Positive Shift, opgeroepen door prosodische grenzen. Deze laatste component speelt binnen dit proefschrift een hoofdrol.

Hoofdstuk 1 van dit proefschrift presenteerde een overzicht van de voor dit proefschrift relevante literatuur. In Hoofdstuk 2 werden twee experimenten beschreven waarin coördinatiezinnen in isolatie zijn bestudeerd. Experiment 1 was een experiment waar de zinnen visueel werden aangeboden. De S-coördinatie zinnen werden gedisambigueerd door een komma na *de boer*, zoals in zin (3). De resultaten lieten geen spoor van een CPS op de komma zien (de resultaten voor de zinnen met een komma verschilden niet ten opzichte van de resultaten voor de zinnen zonder komma). De resultaten op het disambiguerend werkwoord *verdedigde* daarentegen lieten een duidelijk effect zien. Voor de ambigue zinnen (zonder komma) vonden we een N400 gevolgd door een P600 ten opzichte van de gedisambigueerde zinnen (met een komma). Deze resultaten laten opnieuw zien dat een komma S-coördinatie- zinnen disambigueert voordat het disambiguerende werkwoord wordt gelezen. Het is opmerkelijk dat de komma dit effect had ondanks dat in de ERPs op de komma zelf geen effect werd gevonden.

In Experiment 2 van Hoofdstuk 2 hebben we de zinnen uit Experiment 1 in de auditieve modaliteit aangeboden. De S-coördinatie zinnen hadden in plaats van wel of geen komma wel of geen prosodische grens na *de boer*. De resultaten op de prosodische grens waren eenduidig: de prosodische grens riep een CPS op ten opzichte van de zinnen zonder prosodische grens. Dit was geheel in lijn met de literatuur (bijvoorbeeld Steinhauer, Alter, & Friederici, 1999, en Steinhauer, 2003). De resultaten op het disambiguerende werkwoord waren verschillend voor de twee helften van het experiment. In de eerste helft hebben we een LAN gevonden voor de zinnen zonder een prosodische grens ten opzichte van de zinnen met een prosodische grens. In de tweede helft hebben we een P600 gevonden voor de zinnen zonder een prosodische grens ten opzichte van de zinnen met een prosodische grens. Beide resultaten wijzen erop dat de prosodische grens de S-coördinatie zinnen gedisambigueerd heeft voordat het disambiguerende werkwoord optrad.

De hoofdvraag van dit proefschrift, of prosodische informatie en syntactische informatie elkaar onmiddellijk beïnvloeden wanneer ze beschikbaar komen, werd aangesneden in Hoofdstuk 3. Zoals eerder beschreven zouden we dat moeten kunnen meten op de plek waar de prosodische grens samen kan vallen met een syntactische grens (na *de*

boer in de doelzin). Twee experimenten werden uitgevoerd waarin coördinatie zinnen met en zonder een prosodische grens na *de boer* werden aangeboden in verhaaltjes zoals beschreven in Tabel 1. In het eerste experiment was de prosodische structuur altijd in tegenspraak met de uiteindelijke disambiguatie. Dat wil zeggen dat de S-coördinatie zinnen geen prosodische grens bevatten na *de boer*, terwijl de NP-coördinatie zinnen dit wel hadden. In het tweede experiment was dit omgedraaid: de prosodische structuur was hier altijd in lijn met de uiteindelijke disambiguatie. De resultaten in de ERPs van de twee experimenten verschilden niet op de locatie van de aan- en afwezigheid van de prosodische grens (dus na *de boer*). In beide experimenten werd daar een CPS gevonden wanneer de zinnen met een prosodische grens vergeleken werden met de zinnen zonder die grens. Opmerkelijk was ook dat de CPS in beide experimenten kleiner was voor de zinnen in de experimentele context dan in de neutrale context. Met andere woorden, wanneer er een syntactische grens verwacht wordt na *de boer*, en er een prosodische grens aangeboden wordt op deze locatie is de CPS kleiner dan wanneer er geen syntactische grens verwacht wordt. Dit toont aan dat prosodische informatie en de uit de context opgeroepen syntactische informatie elkaar direct beïnvloeden wanneer zij beschikbaar komen. Naast de in Hoofdstuk 3 beschreven analyses op de prosodische grens die gepubliceerd zijn in een artikel in Journal of Cognitive Neuroscience (Kerkhofs, Vonk, Schriefers, & Chwilla, 2007) zijn er in Hoofdstuk 3 nog twee series additionele analyses beschreven.

In Hoofdstuk 4 zijn de resultaten beschreven van de metingen op het disambiguerende zinsdeel van de twee experimenten die reeds in Hoofdstuk 3 werden gepresenteerd. De ERP resultaten op het disambiguerende werkwoord van de S-coördinatiezinnen lieten in Experiment 1 een vroege positieve deflectie zien voor de neutrale context ten opzichte van de experimentele context. De resultaten op de disambiguerende regio van de NP-coördinatiezinnen (het begin van *voor de schuur* in zin (2)) lieten een langdurige positieve deflectie zien voor de experimentele context ten opzichte van de neutrale context. De vorm en timing van beide deflecties kwamen niet overeen met een bekende ERP-component. We hebben de resultaten van beide vergelijkingen geïnterpreteerd als een weerspiegeling van verwerkingsmoeilijkheid. Deze verwerkingsmoeilijkheid trad voor de S-coördinatie zinnen op in de neutrale context, waar er geen syntactische grens werd geïnduceerd na *de boer*. Voor de NP-coördinatie zinnen trad deze verwerkingsmoeilijkheid op in de experimentele context, waar er wel een syntactische grens werd geïnduceerd na *de boer*. Met andere woorden, wanneer de context in tegenspraak was met de uiteindelijke disambiguatie werd een weerspiegeling van verwerkingsmoeilijkheid gevonden.

In Experiment 2 werden zowel voor de S-coördinatiezinnen als voor de NP-coördinatiezinnen geen verschillen gevonden tussen de experimentele context en de neutrale context. Dit is te verklaren vanuit het feit dat in Experiment 2 de prosodische structuur in lijn was met de uiteindelijke syntactische disambiguatie. Dit houdt in dat de zinnen niet ambigu waren. De neutrale versus experimentele context heeft daar geen extra invloed op gehad.

Appendix I rapporteert een aantal technische analyses om het juiste meetpunt in de disambiguerende werkwoorden te bepalen. Hiervoor zijn analyses uitgevoerd op het begin van het disambiguerende werkwoord, op het einde van het disambiguerende werkwoord, en op het theoretische uniekheidspunt van het disambiguerende werkwoord. De resultaten van deze analyses toonden aan dat de keuze van het analysepunt een groot effect kan hebben op de resultaten. In Appendix I wordt beargumenteerd waarom we in dit proefschrift het theoretische uniekheidspunt hebben gehanteerd.

De overkoepelende vraag die we in dit proefschrift hebben willen beantwoorden is of prosodische informatie en syntactische informatie meteen invloed op elkaar hebben wanneer zij beschikbaar komen. De resultaten van de experimenten laten onomstotelijk zien dat dit het

geval is: syntactische informatie en prosodische informatie beïnvloeden elkaar onmiddellijk wanneer zij beschikbaar komen.

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Curriculum vitae

Roel Kerkhofs werd geboren op 8 juni 1979 in Boxtel, Noord Brabant. In 1996 begon hij zijn studie in Nijmegen aan de Hogere Laboratorium Opleiding. Na de propedeuse ging hij in 1997 psychologie studeren aan de Radboud Universiteit Nijmegen. In 1998, na de propedeuse Psychologie, stapte hij over naar de bovenbouwstudie Cognitie Wetenschap waarbinnen hij als specialisme cognitief psychologisch onderzoek koos. Tijdens zijn studie werkte hij als student assistent op het Nijmegen Instituut voor Cognitie en Informatie bij prof. dr. Judith Kroll en op het Max Planck Instituut voor Psycholinguïstiek bij prof. dr. Wietske Vonk. Hij studeerde af in 2001 bij prof. dr. Ton Dijkstra op een ERP-onderzoek naar de herkenning van interlinguale homografen in verschillende taal contexten (Kerkhofs, Dijkstra, Chwilla, & De Bruijn, 2006).

Hetzelfde jaar begon hij aan een AIO-traject waar dit proefschrift en twee artikelen het resultaat van zijn (Kerkhofs, Vonk, Schriefers, & Chwilla, 2007; 2008). Tijdens zijn AIO-aanstelling werkte hij ook als junior docent bij de vakgroep Nederlands aan de Radboud Universiteit.

In 2006 begon Roel Kerkhofs bij het Centraal Bureau voor de Statistiek, waar hij heeft gewerkt als statistisch onderzoeker en functioneel ontwerper. In augustus 2008 maakte hij de overstap naar O&i, een bedrijf dat zich specialiseert in business proces management, change management en business rules management. Hier werkt hij als consultant aan rulemanagement- en verandertrajecten binnen de centrale overheid.

Publicaties:

Kerkhofs, R., Dijkstra, T., Chwilla, D. J., & De Bruijn, E. R. A. (2006). Testing a model for bilingual semantic priming with interlingual homographs: RT and N400 effects. *Brain Research*, 1068, 170 -183.

Kerkhofs, R., Vonk, W., Schriefers, H., & Chwilla, D. J. (2007). Discourse, syntax, and prosody: The brain reveals an immediate interaction. *Journal of Cognitive Neuroscience*, *19*, 1421 – 1434.

Kerkhofs, R., Vonk, W., Schriefers, H., & Chwilla, D. J. (2008). Sentence processing in the visual and auditory modality: Do comma and prosodic break have parallel functions? *Brain Research*, *1224*, 102 – 118.

Kerkhofs, R., & Haselager, W. F. G. (2008). The Embodiment of Meaning. *Manuscrito*, 29, 753 – 764.

Van Dijk, J., Kerkhofs, R., Van Rooij, I., & Haselager, W. F. G. (2008). Can There Be Such a Thing as Embodied Embedded Cognitive Neuroscience? *Theory and Psychology*, *18*, 297 – 316.

Bögels, S., Schriefers, H., Vonk, W., Chwilla, D. J., & Kerkhofs, R. (in press). The Interplay between Prosody and Syntax in Sentence Processing: The Case of Subject- and Object-Control Verbs. *Journal of Cognitive Neuroscience*.